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ABSTRACT

As a part of the REACH (Refrigeration, Electro-Mechanical, Air-Conditioning, Heating) electromechanical cluster, this student manual contains individualized instructional units in the area of residential electrical wiring. The instructional units focus on grounded outlets, service entrance, and blueprint reading. Each unit follows a typical format that includes a unit sheet, information sheets, assignment sheets, and job sheets. The unit sheet is designed to guide the learner through each task and is comprised of two main sections. The first lists all information needed to identify the task and the sequence in which activities are performed. The second section identifies each activity. (Related teacher's guides are available as CE 026 352-355.) (LRA)

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REACH

RESIDENTIAL ELECTRICAL WIRING UNITS

DEVELOPED UNDER CONTRACTUAL AGREEMENT

WITH

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OFFICE OF VOCATIONAL EDUCATION
GEORGIA DEPARTMENT OF EDUCATION
ATLANTA, GEORGIA 30334
CHARLES McDANIEL, STATE SUPERINTENDENT OF SCHOOLS

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OF

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UNIVERSITY OF GEORGIA
ATHENS, GEORGIA 30602

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JUNE, 1980

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RESIDENTIAL ELECTRICAL WIRING UNITS

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REW-02 -- REW-13 . . . . . JIMMY ANSLEY, THOMSON HIGH SCHOOL

RESIDENTIAL ELECTRICAL WIRING (REW)

TEXT ASSIGNMENT SHEET

ASSIGNMENT NO.	TEXT NO.	PAGES	STUDY ASSIGNMENT
REW-01a	7	316-318	Read Sections on Circuit grounding
REW-02			No text assignment
REW-03			No text assignment
REW-04a	7	132-136	Examine figures: 6-25, 6-27, 6-28, 6-29, and 6-30
REW-05a	7	141-143	Read "Bell or Buzza Wiring" and "Chime Circuits", study diagrams in these sections
REW-06a	7	115-119	Read sections on three way and four way switches
REW-07			No text assignment
REW-08			No text assignment
REW-09a	7	271-273	Read section on Service Switch and Distribution Panel
REW-09b	7	295-299	Read Section on Grounding
REW-10			No text assignment
REW-11			No text assignment
REW-12			No text assignment
REW-13			No text assignment

MAJOR BLOCK Residential Wiring **NAME** _____

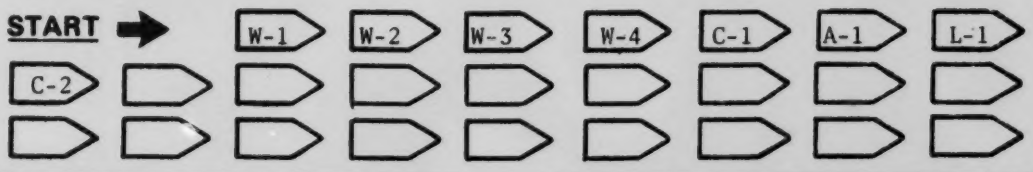
TASK Grounded Outlets (115v-230v)

UNIT Installing 115v Appliance Outlets **TIME (est.)** _____ (act.) _____

UNIT NO REW-01

OBJECTIVE(S)

Install 115v appliance outlets.



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet REW-01a
W-2	Text Assignment REW-01a
W-3	Assignment Sheet REW-01a
W-4	Information Sheet REW-01b
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set REW-01a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet REW-01a
L-2	
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

There is a wide variety of wall boxes used in residential wiring. The most common is the outlet box, or often referred to as a receptacle box. This box is available in aluminum, galvanized steel, and plastic. The most common type used is galvanized steel. They are available in single-gang, gangable, with plaster ears, and without plaster ears. A single-gang box is used for mounting only one receptacle.

A gangable box is used for mounting more than one receptacle at one location. This is done by removing one or both sides of the box allowing you to gang as many boxes together as needed. Plaster ears are used primarily in (old work) when a box is needed to be installed in an existing plaster, wood lath, or concrete wall.

Receptacle boxes are also available with knockouts for installing rigid conduit or electrical metallic tubing, and with built in cable clamps for armored cable or non-metallic sheathed cable.

There are no hard and fast rules for installation heights of receptacle boxes. They will vary with the desires of the homeowner or builder, which should always be followed. Building plans and local codes should also be followed. Listed below are normal recommended installation heights for convenience and appliance outlets.

1. Regular convenience outlet 12"-14" above the floor.
2. Appliance outlet between counter top and kitchen cabinets depending on countertop splash back. 44-46" above the floor.

NOTE: Dimensions given are from finish floor to center of outlet box.

Installation depth of receptacle boxes should be a major concern. Section 370-10 of the code states that boxes installed in non-combustible walls or ceilings such as concrete, tile, etc. shall be so installed that the front edge of the box will not set back of the finished surfare more than 1/4". In walls and ceilings constructed of wood or other combustible materials receptacle boxes shall be mounted flush with the finished surface.

Most receptacle boxes have gage marks on the side or top of the box. These marks are to aide the electrician in determining the proper depth to install a box correctly for wall covering of different thicknesses. Plaster, sheetrock, and wood paneling are wall coverings of different thicknesses.

When installing a receptacle box refer to the blueprints or building contractor to determine what kind of wall covering will be used.

Example: The second mark from the front of the box is used for 1/2" sheetrock. This mark should be aligned with the front edge of the stud to get the proper allowance for a sheetrock wall.

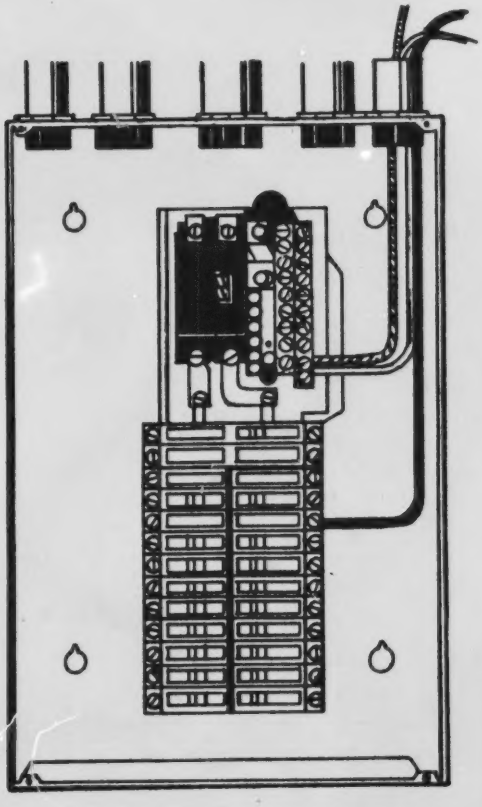
Section 370-13 of the code states. Boxes shall be securely fastened to the surface upon which they are mounted. Boxes shall be supported from a structured member of the building either directly or by using a substantial and approved metal or wooden brace.

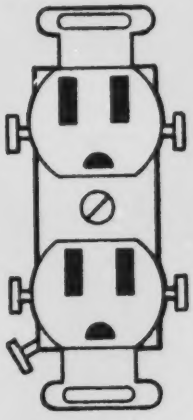
The most common support for receptacle boxes is 16 penny nails mounting the box directly to a wooden wall stud. A nail is inserted through the mounting holes at the rear of the box and nailed to the stud at the desired height and depth.

The instructor will assign two appliances which require 115 volt appliance circuits. One appliance will require a 15 amp circuit and one will require a 20 amp circuit. Examine the nameplate on the appliance and record the necessary information in the chart below.

	Appliance A	Appliance B
Type of Appliance	_____	_____
Full Load Amps	_____	_____
Voltage Required	_____	_____
Breaker Required	_____	_____
Wire Size Required	_____	_____

Use the illustration below to label and draw wires completing the circuit for an appliance outlet. Identify breaker size, wire size and label wires according to hot, neutral and ground.





APPLIANCE
12 amp
115 V.

A 115 volt appliance outlet usually supplies electricity to appliances which are found in the kitchen. The appliance outlet will be very similar to a standard wall outlet. The major difference is that each appliance outlet is on a separate circuit. Also the outlet will be located near the appliance. Some examples of appliances that need individual circuits are refrigerators, window air conditioners, microwave ovens and washing machines. These appliances all have several characteristics in common. Some of these similarities are weight and current draw. The high current capacity is the main reason these appliances need to be on a separate circuit.

As stated before appliance outlets are very similar to convenience outlets and they consist of the same components. The first thing to discuss is the wall box. There are two types on the market today which are used in residential wiring. One type is metal and has clamps built in to secure the wire after it is pulled in the box. The second type is plastic and usually does not have the wire clamps so staples must be used to secure the wire close to the box both types are acceptable by the National Electric Code (N.E.C.) Refer to Figure A.

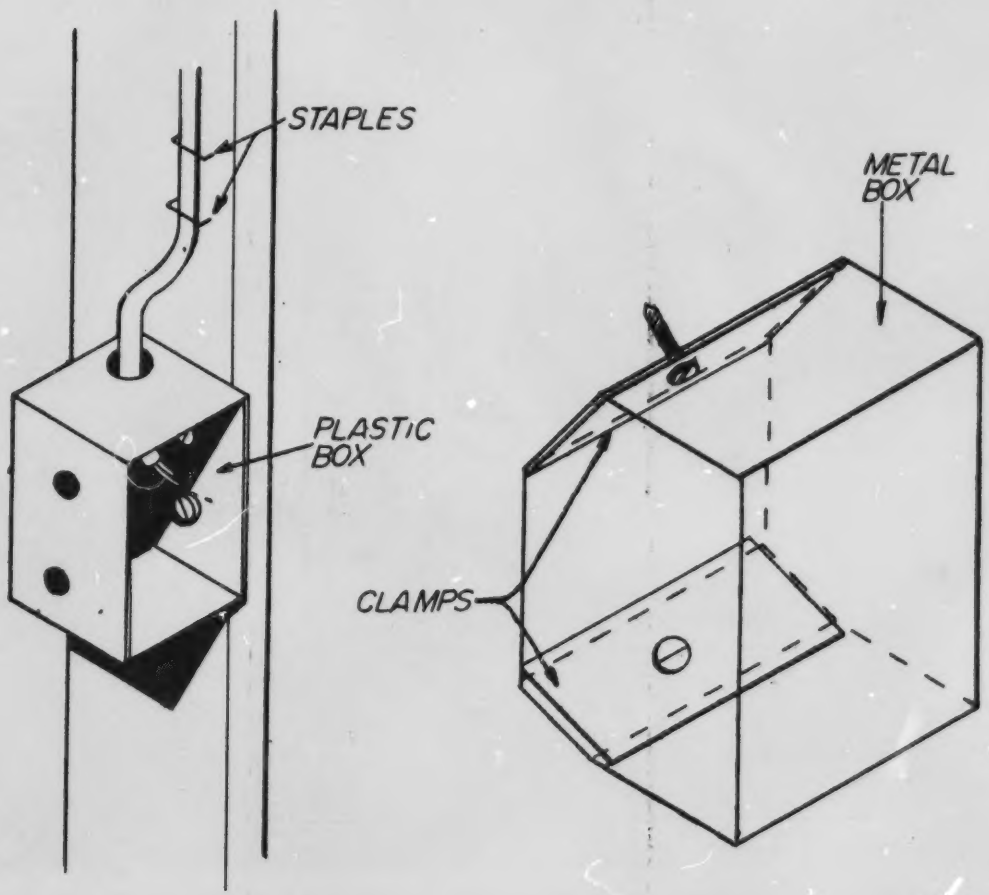


FIGURE A

The wire used most for 115v convenience outlets is 12/2 wg. however sometimes 14/2 wg. can be used. This would be determined by the ampacity of the appliance. The ampacity of the appliance and the wire size would determine the breaker size. For example 12 gage wire is rated at 20 amps and 14 gage is rated at 15 amps. If the appliance is going to pull 16 amps, 12/2 wg. is required. If it only pulls 8 or 10 amps 14/2 wg. can be used. The amperage rating is usually stamped on the name plate of the appliance. The wire and breaker size can be determined by referring to the nameplate of the appliance as shown in Figure B.

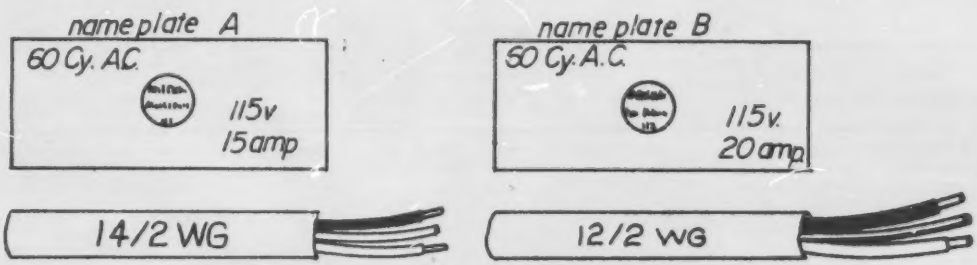


FIGURE B

There are three types of romex wire used in residential wiring as stated in article 336 and 339 of N.E.C.

1. Type NM - The overall covering shall have a flame-retardant and moisture resistant finish. The cable shall have a distinctive marking on the exterior for its entire length specifying the cable type. It shall be permitted to be installed for both exposed and concealed work in normally dry locations. It shall be permitted to be installed in air voids in masonry block or tile walls where such walls are not exposed to excessive moisture or dampness.

2. Type NMC - The overall covering shall be flame-retardant, moisture resistant, fungus resistant and corrosion resistant. It shall be permitted for both exposed and concealed work in dry, moist, damp or corrosive locations, and in outside and inside walls of masonry block or tile. It shall have a distinctive marking on the exterior for its entire length specifying the cable type.

3. Type UF (underground feeder) - The overall covering shall be flame retardant, moisture resistant, fungus resistant, corrosion resistant, and suitable for distinctive marking on the exterior for its entire length specifying the cable type.

NOTE: UL - Underwriters Laboratory Listed and Approved

Romex - Two or more individually insulated wires, within a plastic jacket of insulation.

Romex without ground - Two wires individually insulated within a plastic jacket of insulation.

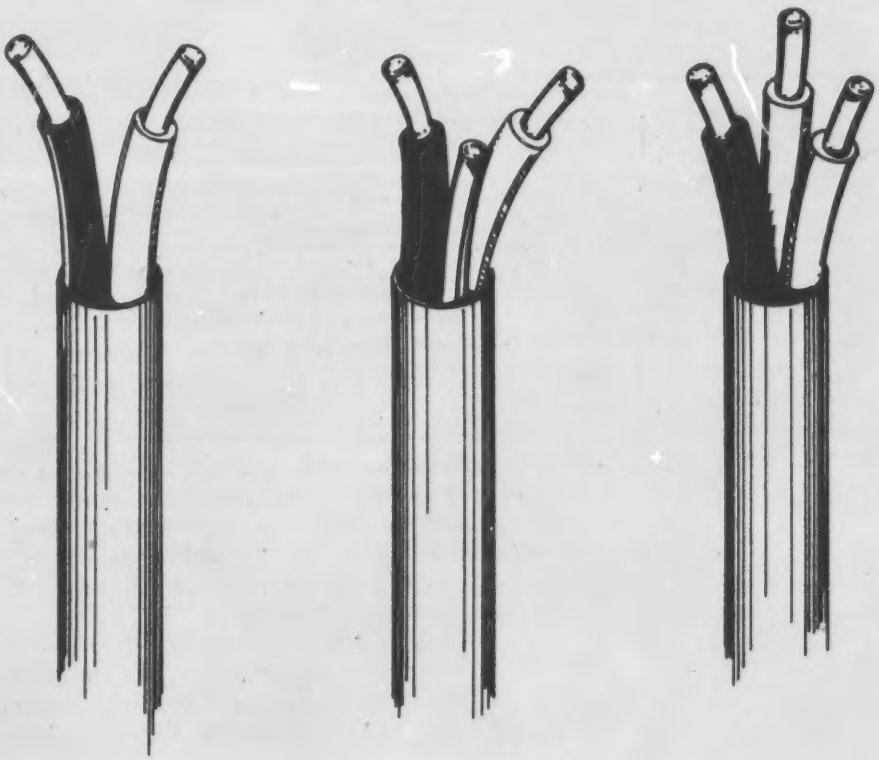
Romex with ground - Two wires individually with a bare ground wire all within a plastic jacket of insulation.

Romex 3-wire - Three wires within a plastic jacket of insulation, all of which are individually insulated.

UF Romex - UF (underground feeder) this type romex wire has a thicker outside jacket of insulation which is weatherproof and sun resistant. Type UF romex is designed for direct burial. UF romex is available without ground, with ground, and 3-wire.

NM - Non-metallic.

AWG - American wire gauge.



The instructor will assign an appliance from which the necessary information can be gathered. Make a list of the materials needed and install a 115v appliance outlet according to NEC standards. Use the following procedures to build the circuit.

Record Information Here		Materials Needed (Include size, type, length, etc.)
1. Assigned Appliance	_____	1. _____
2. Serial Number	_____	2. _____
3. Amperage Rating	_____	3. _____
4. Breaker Size	_____	4. _____
5. Wire Size	_____	5. _____
		6. _____

Procedures:

1. Mount the distribution panel and outlet box.
2. Determine the amperage rating of the assigned appliance.
3. Select the proper size breaker and place into the distribution panel.
4. Select the proper wire size for the installation.
5. Wire the distribution panel and the appliance outlet.

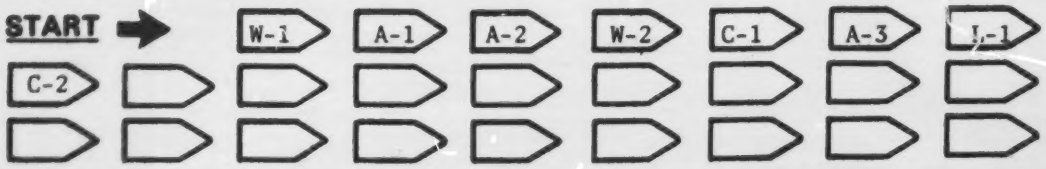
MAJOR BLOCK Residential Wiring **NAME** _____

TASK Grounded Outlets (115v - 230v)

UNIT Installing Convenience Outlets **TIME (est.)** _____ **(act.)** _____

UNIT NO REW-02

OBJECTIVE(S) Install a convenience outlet.



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet REW-02a
W-2	Assignment Sheet REW-02a
W-3	
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set REW-02a
A-2	Slide Set REW-02b
A-3	Slide Set REW-02c
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet REW-02a
L-2	
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

Convenience outlets are installed in a similar manner as appliance outlets, however, there are a few differences. The main difference is that more than one convenience outlet can be installed on a circuit. According to the National Electric Code, all 110-115 general outlets should be rated at no less than 180 watts each. This will allow around 8 to 10 outlets per circuit. The method of connecting the convenience outlet in the panel should be the same, except that every outlet but the last one on the circuit would have an incoming pair of wires and an outgoing pair. Refer to Figure A.

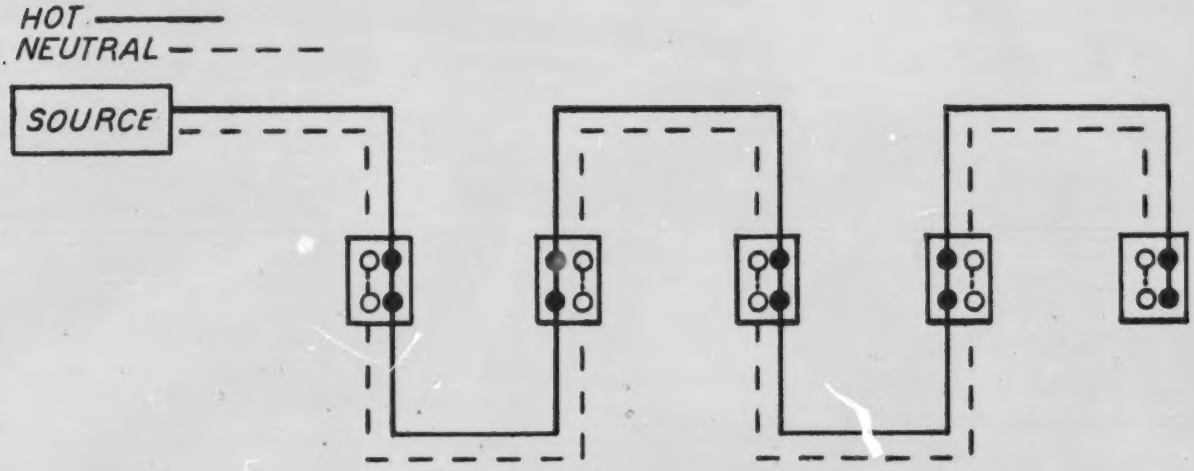


FIGURE A - OUTLET WIRING

The location of convenience outlets are also slightly different from appliance outlets in that their spacing within the room should be accessible from any point in the room. The National Electric Code requires that outlets be near enough to lamps or other electrical devices so that a 6' cord can reach without using hazardous extension cords. Outlets should be 12" from the floor unless otherwise specified by the builder. It also, is useful to have half of the outlets in any particular room on two separate circuits. If a breaker of one circuit switches "OFF" the outlets of the second circuit may still provide electricity to the room. (Figure B).

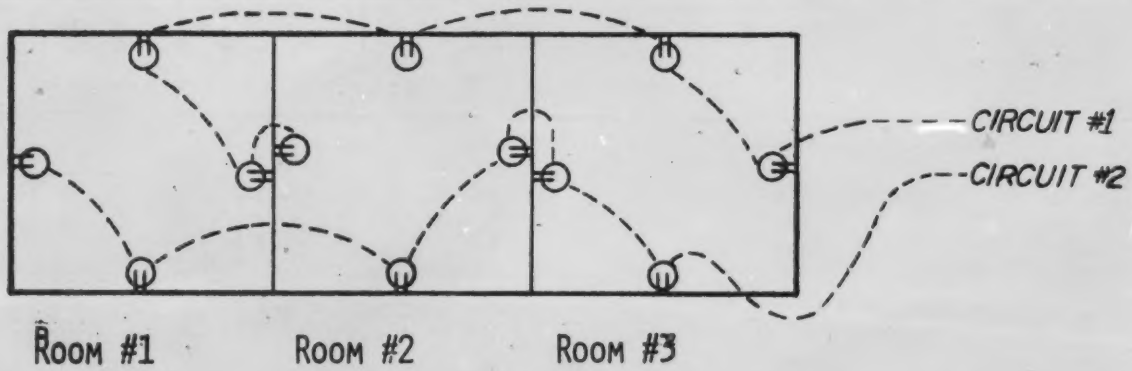


FIGURE B - LOCATION OF OUTLETS

The National Electrical Code, by law, has standardized wiring methods and provides minimum standards to be met. The code requires that electrical cables extend from the box a minimum of 6". To allow easy identification of terminal connections the neutral (silver) terminal will be on the left and the hot (brass) terminal on the right. Usually the grounding (bond) terminal falls on the lower end of the receptacle on the side of the neutral terminal.

Draw in hot, neural and ground wires into the illustrations below. All convenience outlets should be on one circuit.

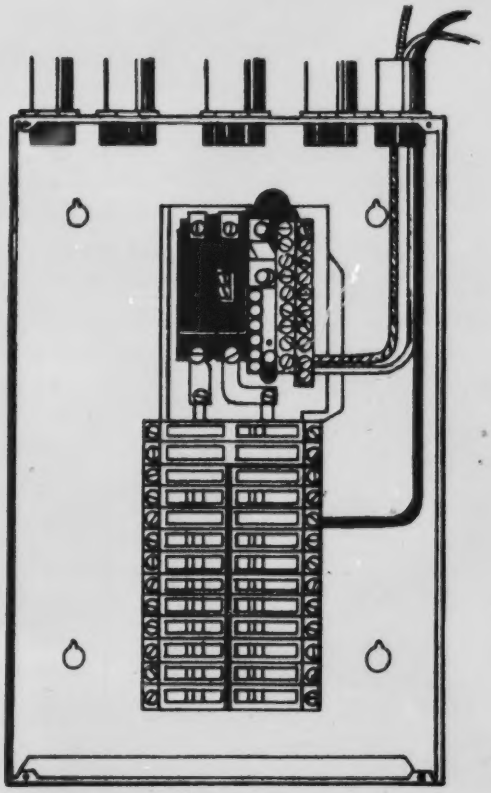
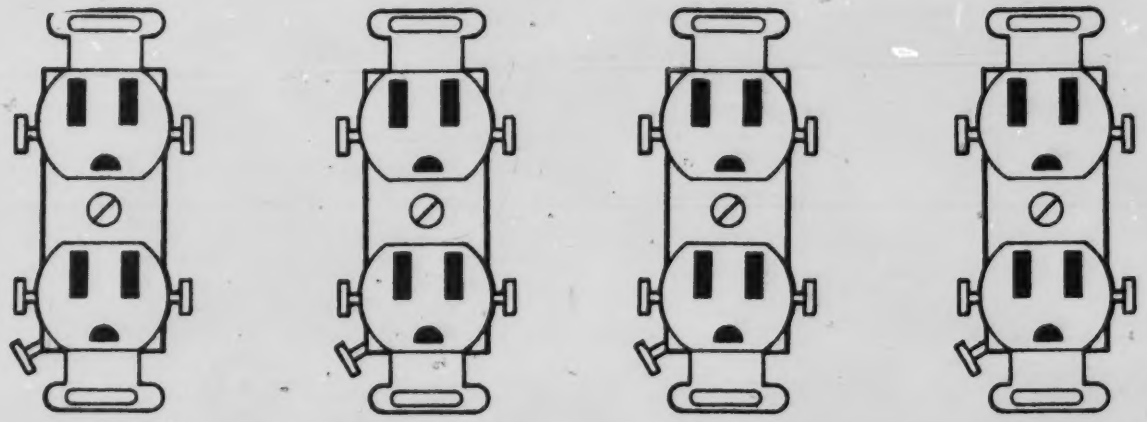


FIGURE C



Make a materials list and wire three convenience outlets and connect them to the distribution panel. Remember, electricians follow standardized color coding to run wires for any electrical purpose. The reason for color coding is to allow different electricians to follow each other and to avoid electrical shock.

A. Neutral Wire--The neutral is always white. It travels from the source to the silver terminal.

B. Load--The device at the point of use which consumes electrical current.

C. Hot Wire--The wire which goes from the source to the brass terminal.

D. Ground Wire (bond wire)--The wire that travels from the panel source to the green terminal on a receptacle or to the body of the load. This wire is usually bare or green insulated wire.

PROCEDURE:

1. Install distribution panel and outlet boxes. (4 outlets)
2. Pull 12-2 wg cable into the panel and outlets. (Remember that a minimum of 6" of wire should extend outside of the box).
3. Wire each of the convenience outlets.
4. Neatly fold excess wire and press it into the outlet box. Connect device to the outlet box.
5. Place face plates on outlets and wire the distribution panel.
6. Test the circuit.

MAJOR BLOCK Residential Wiring NAME _____

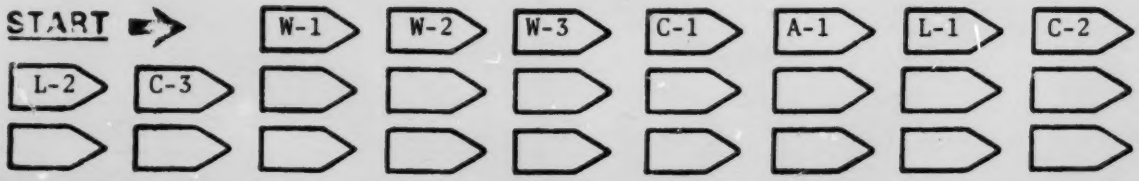
TASK Grounded Outlets (115v - 230v)

UNIT Installing Lighting Outlet TIME (est.) _____ (act.) _____

UNIT NO REW - 03a

OBJECTIVE(S)

Design and install simple lighting circuits.



WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REW -03a
W-2 Text Assignment REW -03a
W-3 Assignment Sheet REW-03a
W-4
W-5
W-6
W-7

AUDIOVISUAL(S)

A-1 REW - 03a
A-2
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REW-03a
L-2 Job Sheet REW-03b
L-3
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4
C-5
C-6
C-7
C-8
C-9

Service Switch and Distribution Panel

The distribution panel serves as the load protector and the main control protector and the main control center for all of the many circuits of the house. These circuits are controlled by individualized breakers within the distribution panel which provide overload protection for each individualized circuit.

The distribution panel is made up of three major components:

1. Service switch - The service switch receives the service entrance cable from the meter and serves as the overload protector to the house. This device (mainbreaker) limits the amount of voltage which can be received by the panel and house.

2. Ground bar - Every circuit in the house must be grounded to the distribution panel. This is usually done by grounding to a bar located inside the fully enclosed box of the panel. The service entrance and the grounding conductor must also be connected to the ground bar of the distribution panel.

3. Distribution terminals - Load distribution of the main circuit breaker is done through the use of two bus bars within the distribution panel. As can be seen in "Figure A", the circuit is picked up on alternate breakers for each 115v circuit. A 230v circuit can be picked up by using adjoining breakers which utilizes 115 volts from each of the two bus bars.

When wiring the distribution panel the sheathing should be removed as the wire enters the panel. Connectors should be tightened on the sheathing at the outside edge of the panel. When a large number of circuits must be installed into the panel it becomes rather crowded. Therefore, all wires inside the panel should be run at distinct 90° angles. Observe the installation in "Figure B" on the next page.

FIGURE A

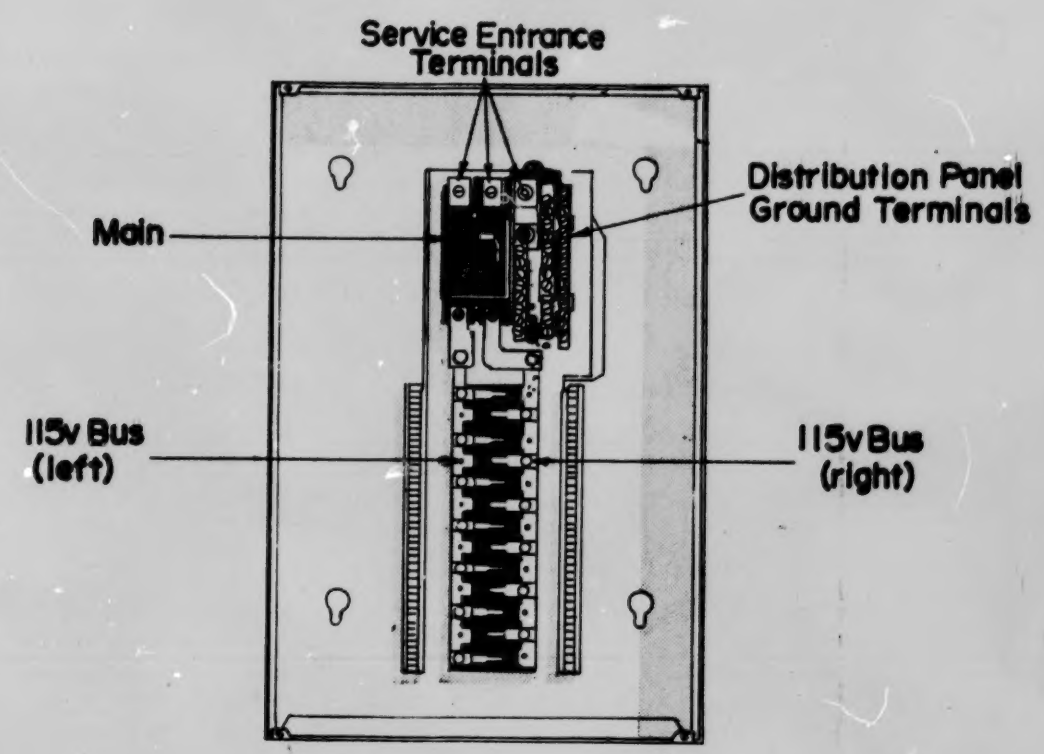
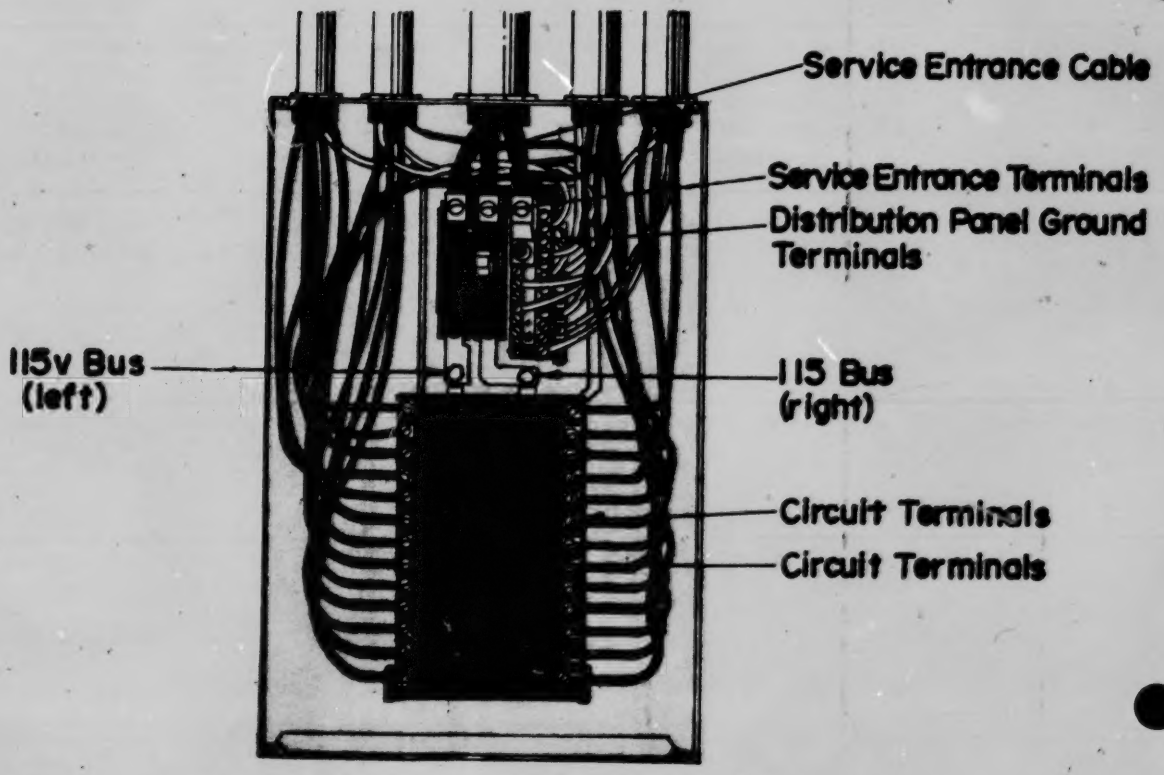
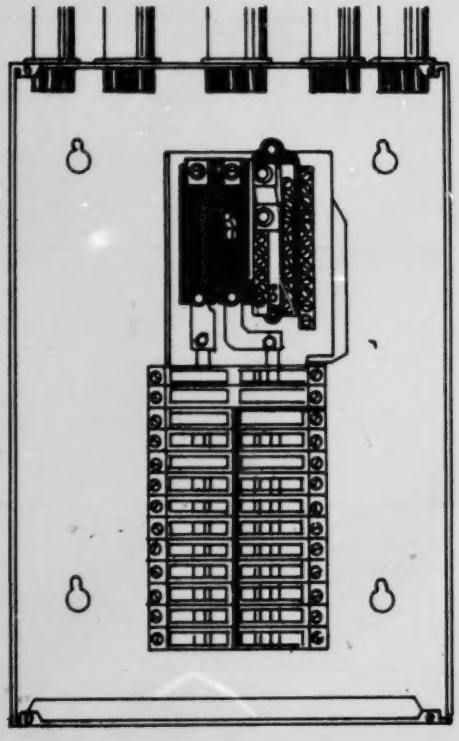
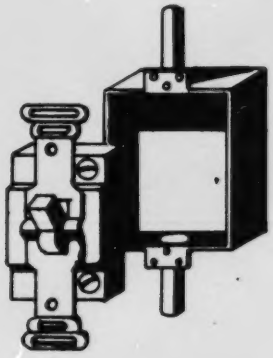


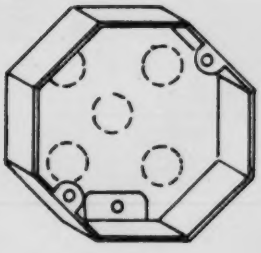
FIGURE B

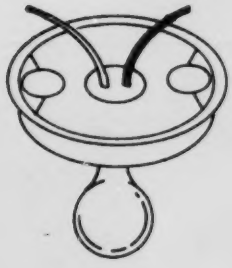


Use the distribution panel, boxes and lighting fixture below to design a simple lighting circuit. Draw the necessary wires into their appropriate positions and label the size and colors. Identify the various components of the circuit; Hot leg, return leg (switch leg), supply, ground, etc. Make sure that all wires inside the distribution panel have been run at 90° angles.









Procedures:

1. List the materials needed to wire the circuit design described in Assignment Sheet REW-03a

2. Secure materials needed to wire the circuit.

3. Mount wall boxes, ceiling boxes, and distribution panel.

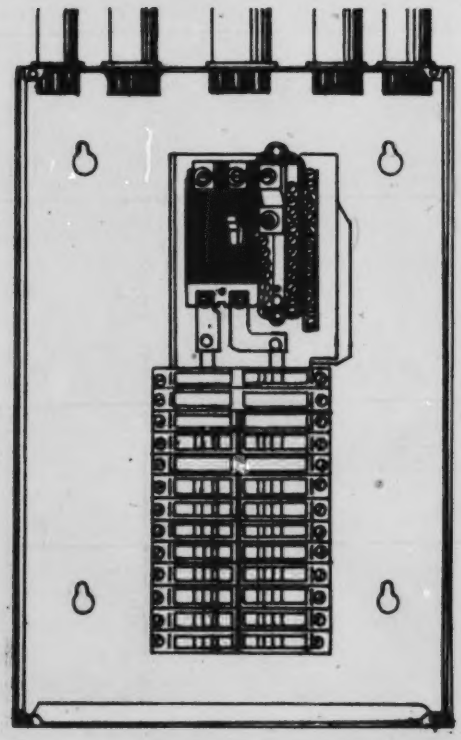
4. Consult the National Electric Code (NEC) for wire size requirements for

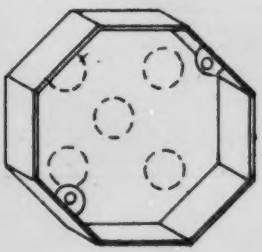
    1. Feeder (supply) _____
    2. Switch leg _____

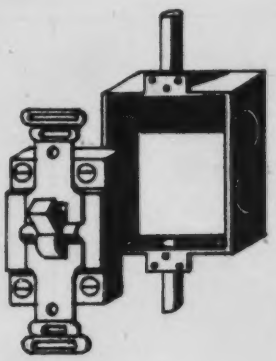
5. Wire the circuit on Assignment Sheet REW-03a according to code requirements.

6. Design the circuit for the components in the diagram below by drawing and labeling wires, splices, etc. into the diagram.

7. Wire the circuit.







Wiring a Single Pole Switch Controlling Two Lamps

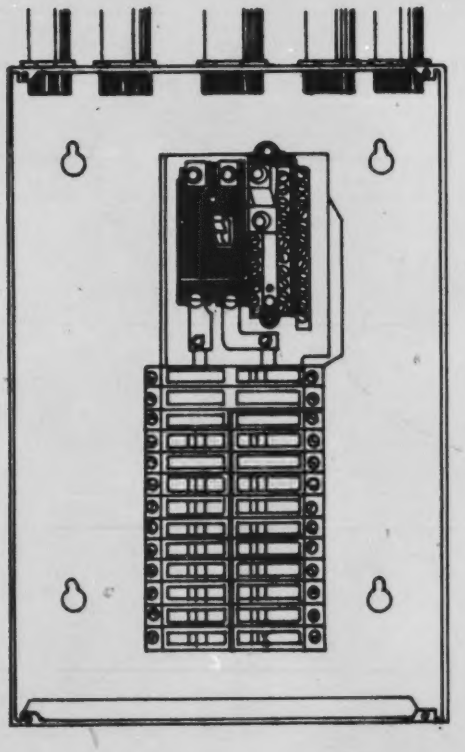
Procedure:

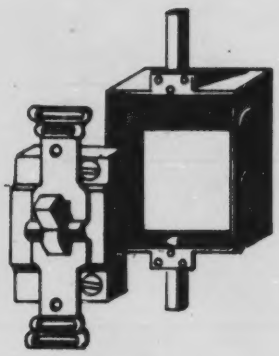
1. Design the circuit for the illustration below by drawing in and labeling wires, splices and grounds. Be sure that switch leg has been identified as hot or return leg. Label wires according to size and color on each circuit component.

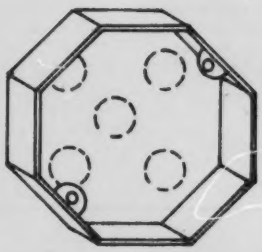
2. Consult the instructor to determine that the circuit design is correct.

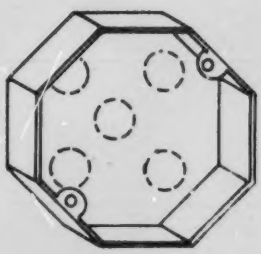
3. List the materials needed to wire the circuit.

4. Wire the circuit below according to NEC requirements.









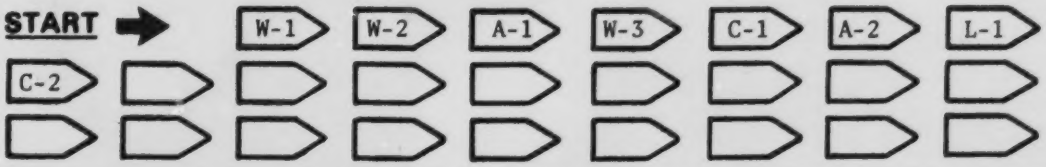
MAJOR BLOCK Residential Wiring **NAME** _____

TASK Grounded Outlets (115v - 230v)

UNIT Installing split switched receptacles **TIME (est.)** _____ **(act.)** _____

UNIT NO REW-04

OBJECTIVE(S) Design and install split and switched receptacles.



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet REW-04a
W-2	Text Assignment REW-04a
W-3	Assignment Sheet REW-04b
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set REW-04a
A-2	Slide Set REW-04b
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet REW-04a
L-2	
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

Stack switches
Switched receptacles are quite common in modern homes today. Their most frequent use is with overhead lighting, however, many areas of the house may also utilize wall switch controlled lamps. Wall switch controlled lamps and overhead lighting may also be used in combination. When this is the case the top portion of the switch will control overhead and the bottom will control lamps. This will permit use of one without using the other. Duplex receptacles may be used in the same way.

Usually standard ~~switches and~~ receptacles can be converted into a split receptacle ~~or combination switch~~. This can be done by removing the plate or jumper which ties the terminals together. If both units are to be fed from the same circuit, only the plate for the hot leg terminal should be removed. If separate circuits are desired, plates for both hot and neutral terminals must be removed.

Switches and receptacles may be purchased which are manufactured in a split arrangement. These devices will of course be more expensive than the standard units. If the builder desires to have this type of device the extra cost should be considered in the job estimate. Another device which is commonly used is the combination switch and receptacle. It provides for the receptacle to remain hot whether or not the switch is "on."

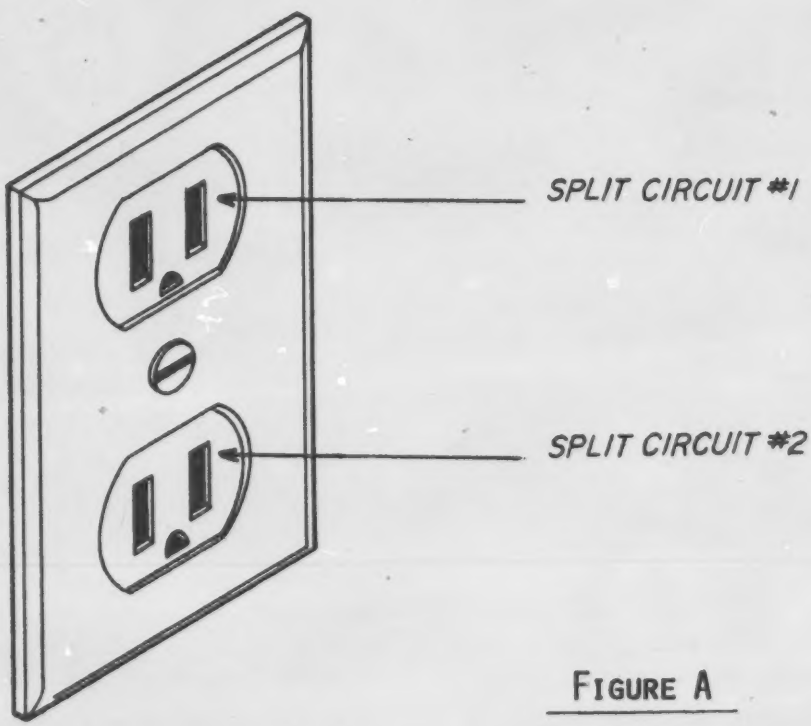


FIGURE A

Use the Figure B below to draw in wires making the receptacle of the combination switch hot regardless of the position of the switch. Indicate the condition of the jumper plate which connects the terminals. Figure C should be designed in a way that the top of the receptacle is one circuit and the bottom on a completely separate circuit. Be sure to indicate the condition of the jumper plate.

	HOT
	NEUTRAL
	GROUND

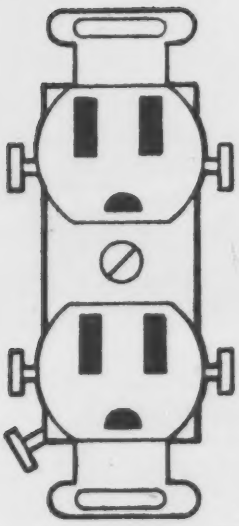


FIGURE B

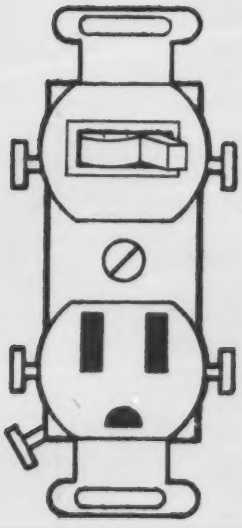


FIGURE C

Secure the material needed to wire two circuits. One should be a combination switch and receptacle and the other should be a split receptacle which is fed by two separate circuits. Use the diagrams on Assignment Sheet REW-04a as a reference. Both outlets should be wired into a distribution panel and should comply to standards set forth in the National Electric Code (NEC).

1. Mount distribution panel and outlet boxes.
2. Rough in necessary circuit wires.
3. Wire distribution panel.
4. Wire each outlet in the appropriate manner.
   A. Combination switch and receptacle (switch should control a light)
   B. Combination split receptacle
5. Make sure that each outlet is grounded in the appropriate manner

MAJOR BLOCK Residential Wiring **NAME** _____

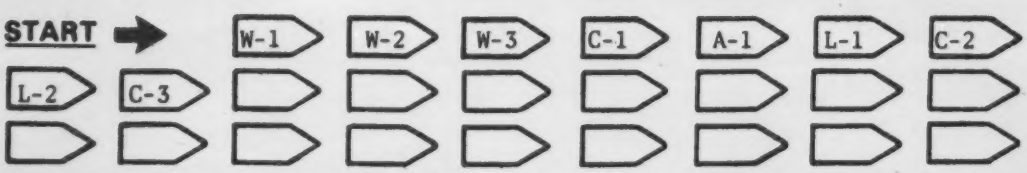
TASK Grounded Outlets

UNIT Installing a Door Bell Circuit **TIME (est.)** _____ **(act.)** _____

UNIT NO REW-05

OBJECTIVE(S)

Design and install one and two button door bell circuits.



WRITTEN ASSIGNMENT(S)

W-1	Text Assignment REW-05a
W-2	Information Sheet REW-05a
W-3	Assignment Sheet REW-05a
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set REW-05a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet REW-05a
L-2	Job Sheet REW-05b
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

Bell and chime circuits are quite simple to install once you understand the parts and the operation of each. Look at Figure A to identify the components as they are explained.

Transformer

The step down transformer reduces the voltage from 115v ac to 16v ac. Most doorbell circuits operate on or around 16 volts. This is to allow the use of much smaller wire on the secondary bell circuit than is used on the main circuits of the house. The primary circuit (115v) current must be wired with at least 14 gage wire and fused accordingly.

Chime

Most chimes today have connections for front and back doors. However, both are not necessary. The chime consists of two electro magnets. When voltage is applied, the magnetic force causes a plunger to move forward and strike a chime. The front door plunger moves up and back giving a two tone chime and the rear only moves forward to sound a one tone chime. Pay close attention to the wiring connections in Figure A. Note the terminal marked transformer. It is a common connection between the two coils.

Front & Back Door Buttons

The two buttons are identical. The buttons are only momentary switches that stay closed as long as they are being pushed.

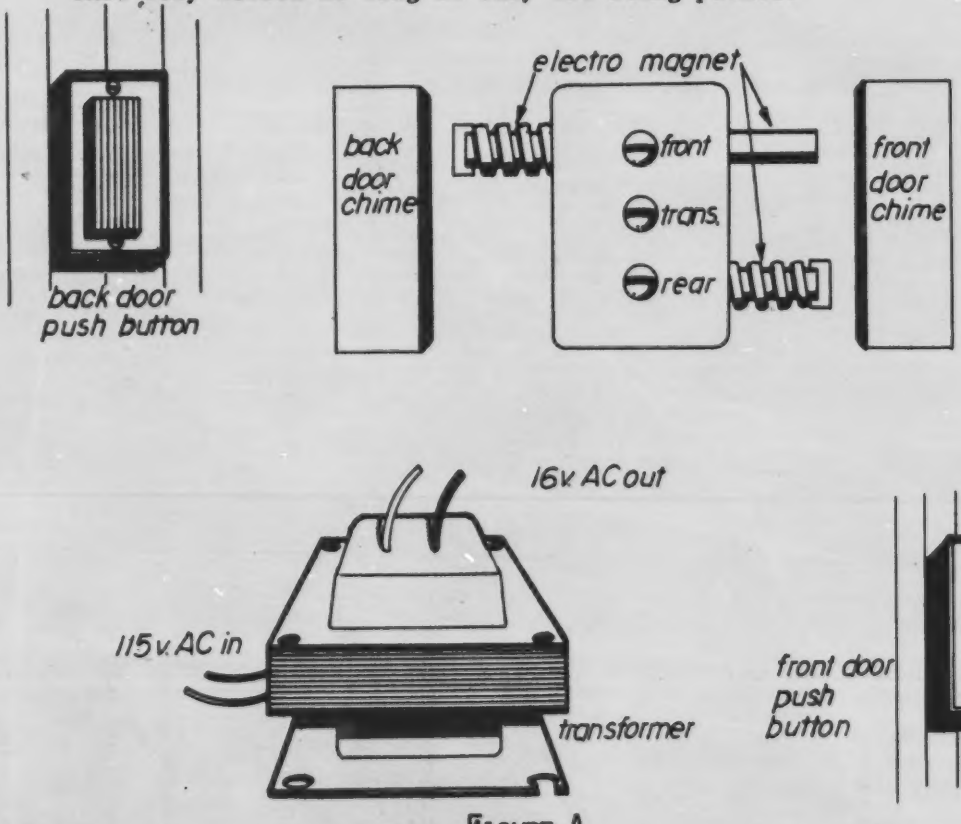
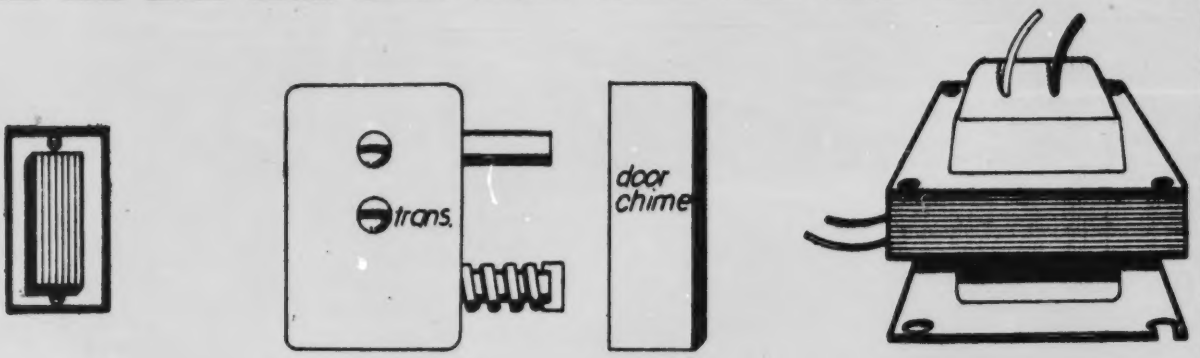


FIGURE A

Draw in the correct wiring for the one and two button station on the illustration below. If further information is needed refer to the reading assignment. Label the wire size and voltage of both the primary and secondary circuits.

"One Button Station"



"Two Button Station"

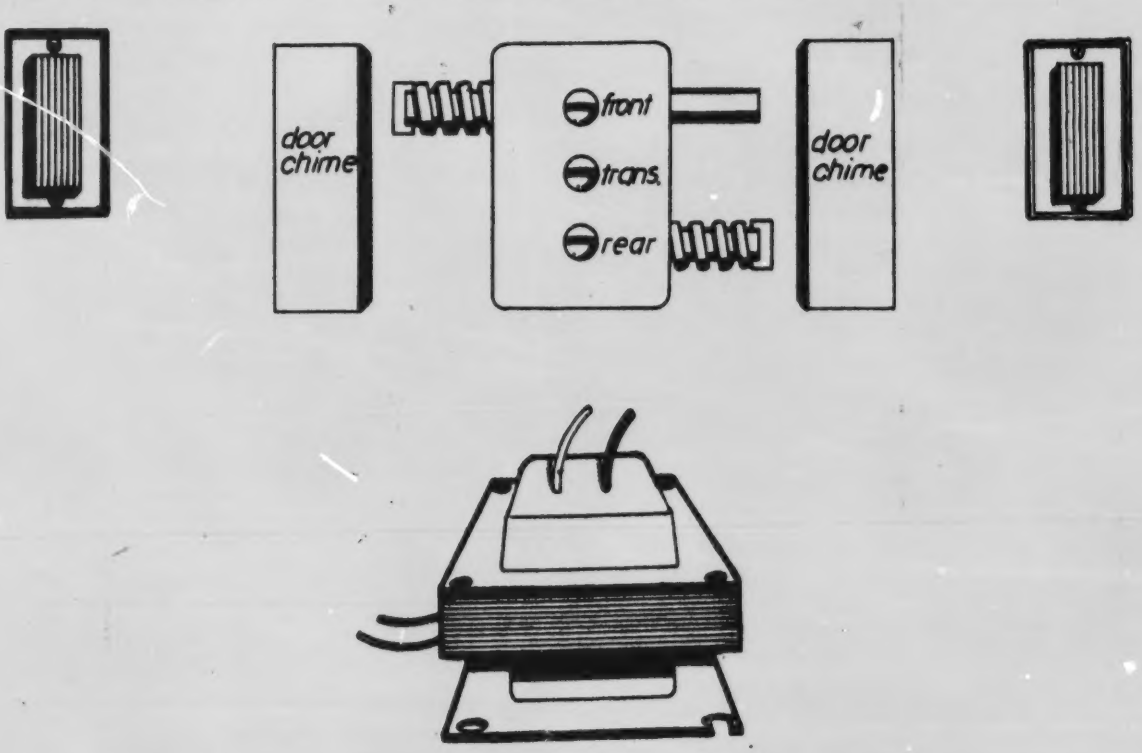


FIGURE B

List the necessary equipment to wire a one button door bell circuit on this paper, (identify rating of transformer). Show this to your instructor and wire the circuit. Ask the instructor to check the wiring.

Two Button Door Bell Circuit Components and Materials

Procedures:

1. Select location of bell or chimes.
2. Identify accessible location for transformer and install.
3. Pull low voltage wire. (Secondary circuit)
4. Mount door push button.
5. Wire push button, transformer and chimes.
6. Connect to primary circuit.
7. Test door bell.

List the necessary equipment to wire a two button door bell circuit on this paper, (identify rating of transformer). Show this to your instructor and wire the circuit. Ask the instructor to check the wiring.

Two Button Door Bell Circuit Components and Materials

Procedures:

1. Select location of bell or chimes
2. Identify accessible location for transformer and install.
3. Pull low voltage wire. (Secondary circuit)
4. Mount front and rear door push button.
5. Wire push buttons, transformers and chimes.
6. Connect to primary circuit.
7. Test door bell.

MAJOR BLOCK Residential Wiring **NAME** _____

TASK Grounded Outlets

UNIT Installing a Three-Way Switch **TIME (est.)** _____ **(act.)** _____

UNIT NO. REW-06

OBJECTIVE(S)

3 Design and install a three-way switch

START ➡ W-1 W-2 W-3 C-1 A-1 L-1 C-2

L-2 C-3

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REW-06a
W-2 Text Assignment REW-06a
W-3 Assignment Sheet REW-06a
W-4 _____
W-5 _____
W-6 _____
W-7 _____

AUDIOVISUAL(S)

A-1 Slide Set REW-06a
A-2 _____
A-3 _____
A-4 _____
A-5 _____
A-6 _____
A-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REW-06a
L-2 Job Sheet REW-06b
L-3 _____
L-4 _____
L-5 _____
L-6 _____
L-7 _____
L-8 _____
L-9 _____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 _____
C-5 _____
C-6 _____
C-7 _____
C-8 _____
C-9 _____

Three and Four-Way Switches

Three-way switches are very common in most homes. This is why it is important to understand how they work, why they work and how to install them.

Three-way switches are used in hallways, stairwells, and rooms with more than one entrance. Three-way switches must be used when a light needs to be turned on or off from one point. Four-way switches are used along with three-way switches. If a circuit requires three switches, two will be three-way switches and the third will be a four-way switch.

The circuit of a three-way switch is shown in Figure A below. Notice that one terminal is common between the other two. This is called the common terminal. The hot wire connects to the marked screw on one switch. The marked screw on the second switch must connect to the light. The remaining two screws are called traveler terminals, the wires that attach to these are called travelers. They are usually the red and white wire of the three wire conductor. As long as they are connected to the traveler terminals, the traveler wires must be correct. Examine the drawing below to see how the circuit must be wired. If both switches connect to a matching wire, the load is on, if they don't match, the load is off.

There are two basic methods of wiring three-way switches. The one just discussed where the three-wire conductor is run from switch to switch. The three-wire conductor sometimes goes from each switch to the light and the switch leg is not needed. The travelers can go straight through from one switch to another. The remaining black wires serve as line and load wires. Look at figure B on the next page for more detail.

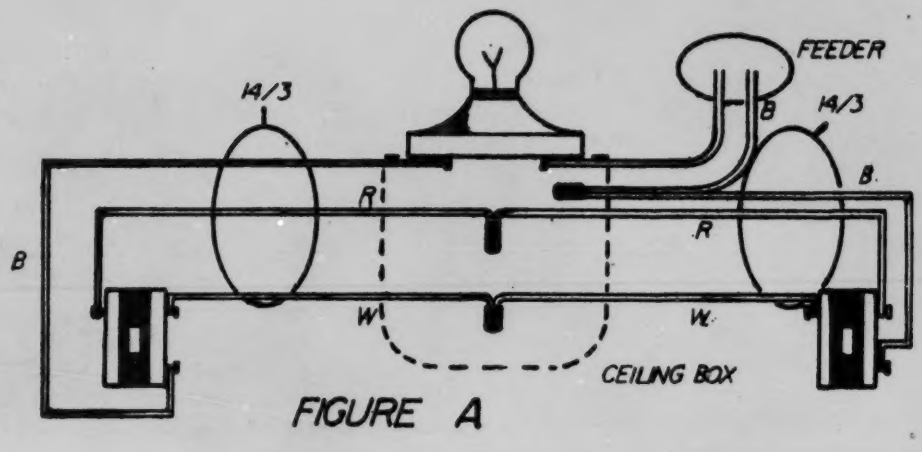


FIGURE A

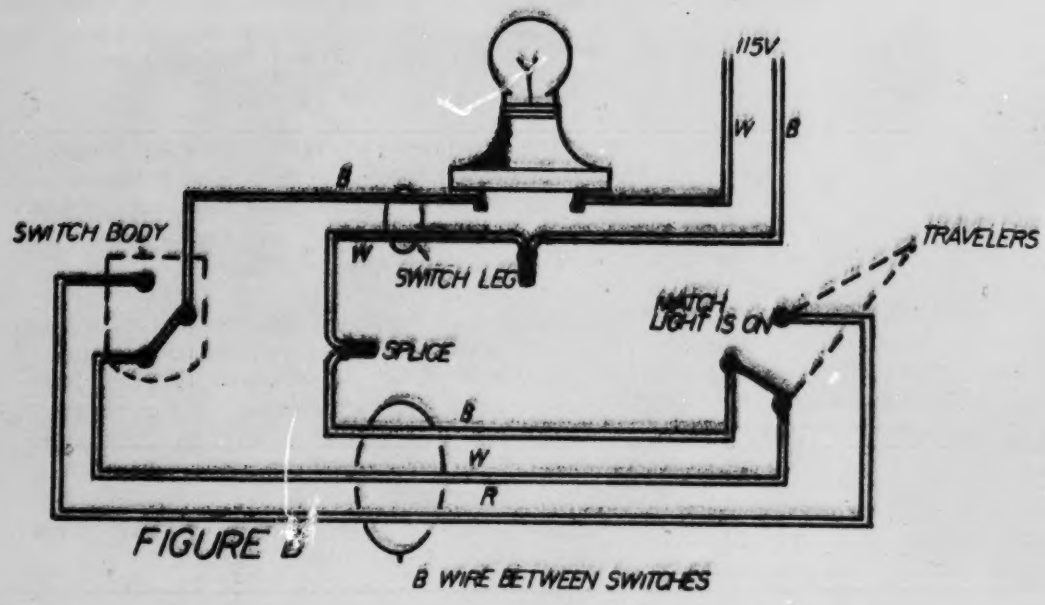
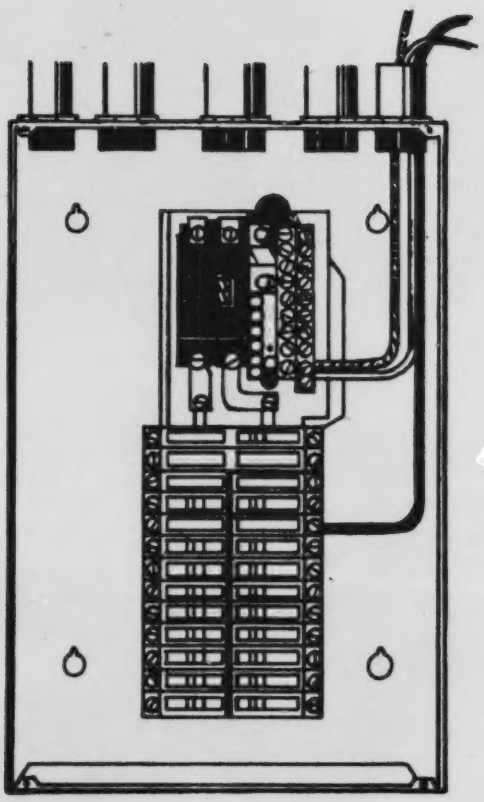
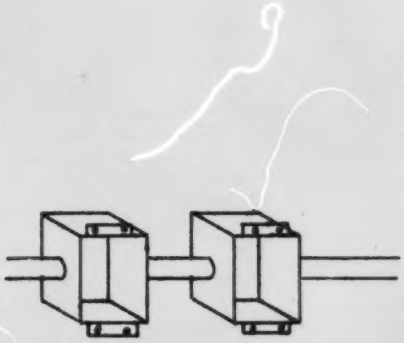

115V
W
B
B
SWITCH BODY
W
SWITCH LEG
TRAVELERS
MATCH LIGHT IS ON
SPLICE
B
W
L
R
B WIRE BETWEEN SWITCHES

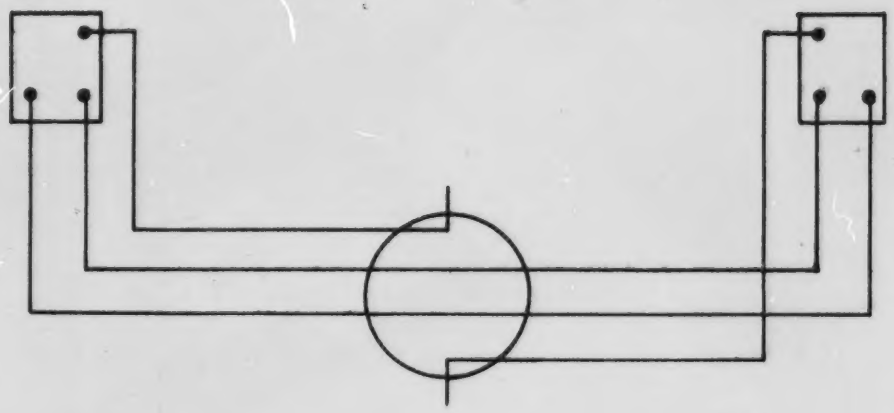
FIGURE B

Below are illustrations of the components necessary to wire a three-way switch circuit. Draw in the wires and color code them. The instructor will check the work before wiring.

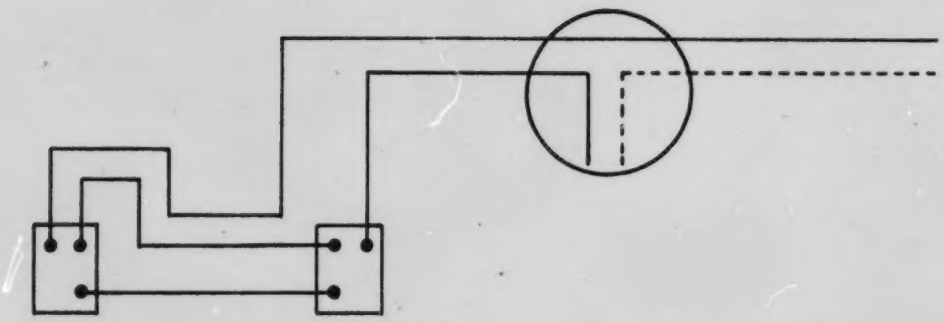




Make a list of all the material needed to wire a three-way switch (using the three wire from switch to switch and switch leg method). Show this list to the instructor, and wire the switch below.



Wire the circuit below. The three-way switch should control two lights.



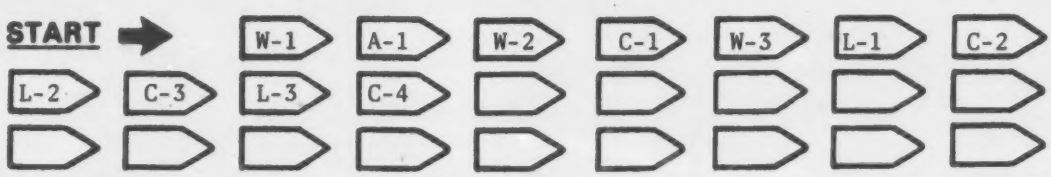
MAJOR BLOCK Residential Wiring **NAME** _____

TASK Grounded Outlets (115v - 230v)

UNIT Installing 230v Circuits & Outlets **TIME (est.)** _____ **(act.)** _____

UNIT NO REW-07

OBJECTIVE(S) Install 230v circuits from the service entrance panel to a junction box, flush mount receptacle, and a surface mount receptacle.



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet REW-07a
W-2	Assignment Sheet REW-07a
W-3	Information Sheet REW-07b
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set REW-07a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet REW-07a
L-2	Job Sheet REW-07b
L-3	Job Sheet REW-07c
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

There are many types of 230 volt outlets and connections because there are many types of appliances to be connected in the home. Figure A shows various types of outlets and amperage use. Some appliances don't require outlets as they tie to a junction box, located on or near the appliance.

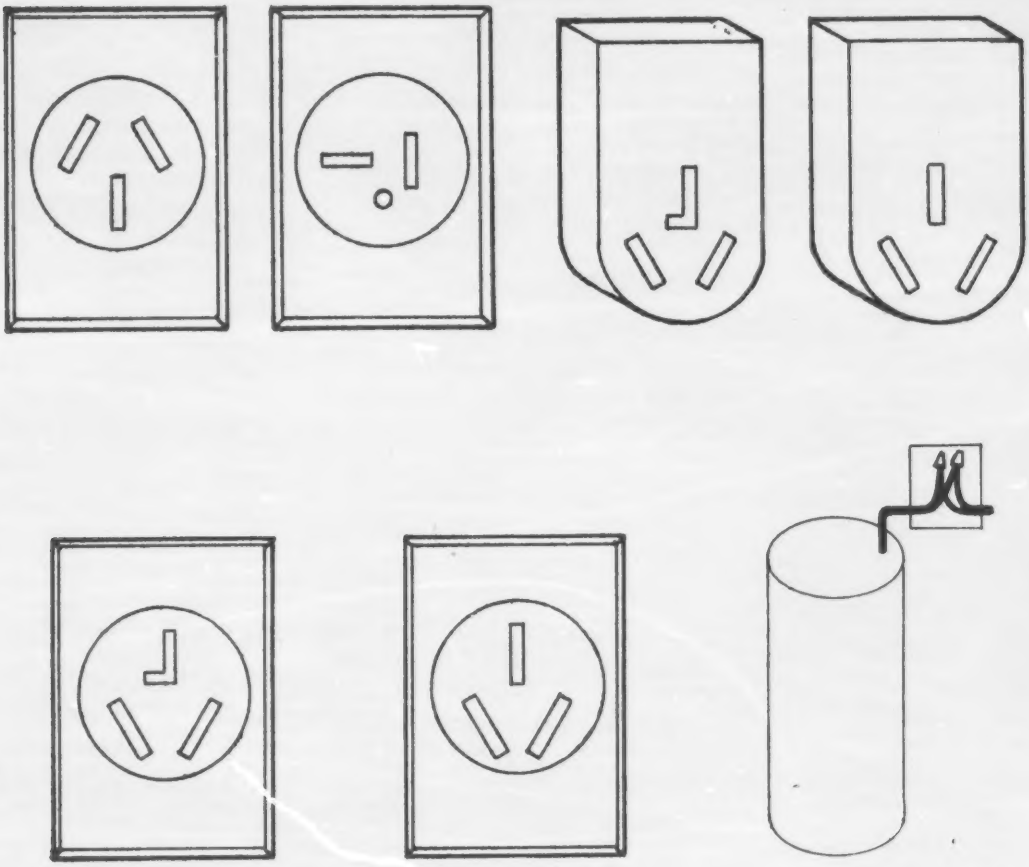


FIGURE A

230 volt breakers are often called double pole breakers because they are made up as two single pole breakers connected by a tie barrior (Figure B-1). 230 volt single pole breakers (Figure B-2) are wider than 115 volt breaker.

The amount of current an appliance requires determines the amperage rating of the 230 volt breaker and the wire size between the breaker and outlet or connection. Figure C is a chart showing current rating, breaker size and wire size for different appliances. Most circuit breakers are rated larger than the appliance amperage draw. This is because breakers are not

made in all sizes, and there must be a certain amount of overcurrent protection for start up.

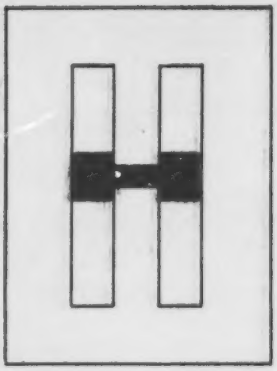


FIGURE B-1

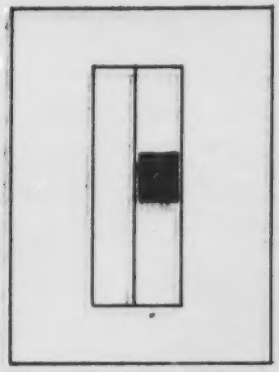


FIGURE B-2

	Current	Voltage	Breaker Size	Wire Size
Hot Water Heater	21A	230v	30amp	12/2wg
Range	50A	230v	60amp	6/3 copper
Dryer	24A	230v	30amp	10/2wg
Oven	24A	230v	30amp	10/2wg
Surface Unit	24A	230v	30amp	10/2wg
Air Conditioner	20A	230v	30amp	10/2wg
Air Conditioner	12A	230v	20amp	12/2wg
Furnace	90A	230v	100amp	No. 2 Copper

FIGURE C

Assignment Sheet REW-07a

Fill in the necessary information in the chart below. Go to the stock room and secure a breaker, the correct wire, and outlet. Show the components you have selected to the instructor for approval.

	FLA	BREAKER	VOLTS	WIRE	TYPE OUTLET
Dryer					
Hot Water Heater					
Range					
Window A/C					

A 230 volt outlet is a heavy duty source that will furnish twice as much voltage as the 115 volt outlet it is used for most major appliances in the home. Several different designs will be discussed such as flush and surface mount types.

On a 230 volt grounded receptacle, only one place is provided to plug an appliance or tool. Appliances that normally plug into this type receptacle are heaters, air conditioners, and some heavy duty tools.

There are three wire terminals on the back side of the receptacle. Two of these are for hot wire connections while the other is for the ground wire. When using any 230 volt wiring, it is not necessary to have a neutral wire as is the case in 115 volt wiring. One of the screws will be green. This is where the ground wire will connect. Each hot wire will carry 115 volts and connects to the remaining terminals. When a 230 volt receptacle has wires properly connected to the terminals, the bare wire or ground wire is connected to the green screw. The two hot wires are connected to the other two terminals and are interchangeable. The end of the wire is looped and fits around the screws in a clockwise direction. Always turn the loops this way. As the screw tightens it also tightens the wire. If the loop is turned counter clockwise, the screw tends to push the wire loose as it tightens.

10-2 with-a-ground is the wire most commonly used for 230 volt receptacles. The ground wire is normally not insulated. However, if the ground wire was insulated it would be green. Depending on the amperage draw of the appliance other wire sizes may be used.

After determining which is the ground wire the remaining two wires will be hot. One of these two wires is white and used as a hot wire where ordinarily in 115 volt wiring the white wire is neutral. There are one or two other exceptions where the white wire is used as a hot wire, but these will be discussed later.

With a 230 volt receptacle connection in the distribution panel, the ground wire connects to the ground and neutral bar by use of the screws provided for that purpose. The two hot wires connect to two separate fuses and each fuse provides 115 volts. When combined this gives 230 volts. The white wire will be connected in exactly the same manner as the black wire.

The connections for a 230 volt circuit in a circuit breaker box are very similar to those in the fuse type box. The ground connects exactly the same way. The two hot wires connect to a circuit breaker instead of fuses. A circuit breaker is made to either carry 115 volts or 230 volts. If it carries only 115 volts it will have only one terminal. If it is for 230 volts as this one is, it will have two terminals. It makes no difference

whether the white wire connects at the top or at the bottom of the circuit breaker. The connections should always be checked to make sure they are very tight since a loose connection can ruin an appliance in a very short time as well as the possibility of starting a fire.

In a circuit breaker box, the ground and neutral bar are generally in the upper right corner. To the left and running almost the full length of the box are two metal bars. At the top of these is the main breaker. When this breaker is in the off position, all power stops. If the breaker is in the on position, both bars will have power. Each bar carries 115 volts.

Surface mount 230v outlets are commonly used in range and dryer applications. The receptacle will have a different plug in design for each different amperage rating.

A dryer outlet is usually rated at 30 amps and uses 10/2 wire with a ground. The internal connections are basically the same as flush mount outlets previously described. The ground is center bottom and the hot wire connections are top left and right. The wire goes behind the built in clamps and tightened. The box connector supplied with the outlet should be used. A range receptacle connection is like a dryer outlet connection except a 6/3 copper wire is used. This outlet is rated at 50 amps.

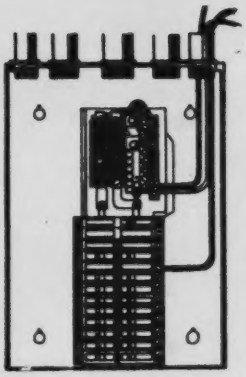
The connections in the fuse panel are somewhat different in dryer and range applications because pullout fuse blocks must be provided for circuits over 30 amps. However, the connections for all 230 volt circuits in a breaker panel are the same except for breaker size. This is determined by the wire size. Refer to a wire chart for this information.

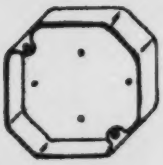
Some appliances don't require outlets. They are connected by using junction boxes. Appliances such as hot water heaters, drop-in ranges, surface units and built in ovens, require a "J" box connection. The wire that is used for most hot water heaters is a 10 gauge size and there are three conductors. The current needed for most hot water heaters is 220 volts. One wire can only carry 110 volts, so two hot conductors must be used. There also must be a ground wire for the frame and tank of the hot water heater. When using 220 volts and 2 hot wires, it is necessary to have a separate neutral wire. Taking the preceding facts into consideration, it can be seen that both the white and black wires will be used as hot conductors. That leaves the bare wire as the bond grounding wire. In some cases the ground wire has to be insulated also. If this is done it is always colored green.

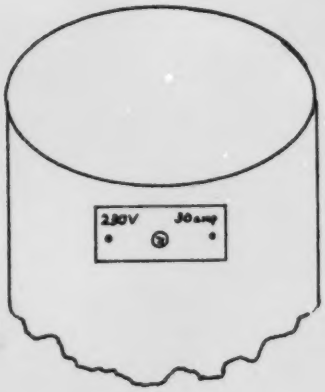
Most surface units and built in ovens have a metal flex cable pre-attached. This is connected to the supply wire at the junction

box. Usually an 8 gauge wire is sufficient for this installation. Eight gauge wire is a fairly large cable so a large enough junction box must be used. Generally a 4" junction box 2" deep will work. Be sure to install the box so that the cable enters the split bolt. Connectors or crimp sleeves are usually used for the electrical connections. These must be taped well. Make sure all connections are tight before the cover is installed on the breaker box. Connections in the fuse and breaker panels are the same as any other 230 volt outlet. Breaker size is determined by the circuit ampacity.

Draw in the circuitry shown from the panel to the junction box to the hot water heater. Make a splice in junction box. Show the correct breaker and wire size in the space provided.

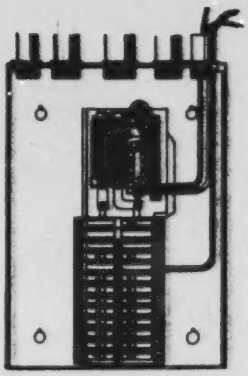


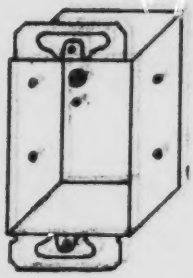


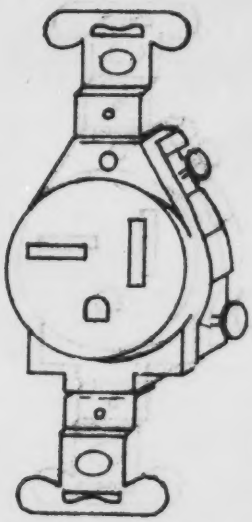


Show this drawing to the instructor before securing the components to wire the actual circuit. Upon instructor's approval secure parts and tools and wire this circuit in your assigned area. Have the instructor check your work then disassemble and clean up.

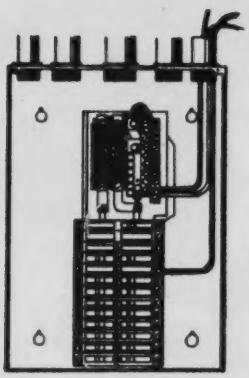
Flush mount 230 volt receptacles are used on exposed wall spaces and installed much like an appliance outlet. Most window air conditioners use a flush mount 230 volt receptacle. Draw in the window A/C circuit below for a 16 amp unit. Determine breaker size, wire size and record it in the space provided. Show drawing to your instructor. Upon instructor approval secure the necessary parts to wire the circuit. Have the instructor check the work and disassemble.

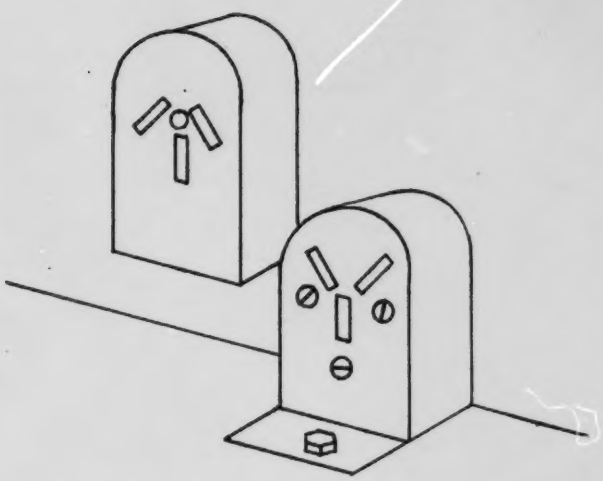






Surface mount receptacles are very common in residential wiring. The primary use is for free standing ranges and dryers that plug in. They come in two sizes, 30 amp and 50 amp. For this assignment use a 50 amp range. Draw in the circuitry below and state wire and breaker size in the parts from the stock room and wire the circuit. Have the instructor check the work before disassembling the panel.





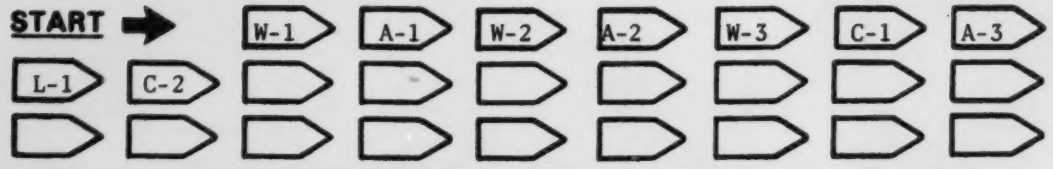
MAJOR BLOCK Residential Wiring **NAME** _____

TASK Service Entrance

UNIT Installing Service Entrance **TIME (est.)** _____ **(act.)** _____

UNIT NO REW-08

OBJECTIVE(S) Design and install a temporary end service entrance.



WRITTEN ASSIGNMENT(S)

W-1	Text Assignment REW-08a
W-2	Information Sheet REW-08a
W-3	Assignment Sheet REW-08a
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set REW-08a
A-2	Slide Set REW-08b
A-3	Slide Set REW-08c
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet REW-08a
L-2	
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

Most homes receive their electrical power through a network of transmission lines, transformer banks and generating stations. When the power reaches most homes it has a voltage rating of 230 volts, 60 cycles and a current rating of either 100 amps, 150 amps or 200 amps. The load in the house determines amperage rating required thus governing the size entrance wire required.

The entrance cable is a three wire cable with two insulated conductors and one wrap around ground or neutral wire. All this is housed in an outer plastic or fabric insulation. The entrance cable is made of aluminum and comes in various sizes depending upon the current that it is required to carry. A 200 amp service requires a 4/0 aluminum service entrance (SE). A 150 amp service requires a 2/0 aluminum service entrance (SE) and a 100 amp service requires the use of two fused panels. One panel for 110-115 volt circuits and one for special 220-230 volt circuits.

Methods of installing the entrance may vary somewhat depending on the construction of the home and type of service available, however, either are acceptable methods. The underground service is useful to avoid overhead wiring from crossing trees and property. The service entrance wire should be encased by 2" conduit from the meter base to three feet (3') below ground level to a point six feet (6') away from the building. A sweeping el should be used so that the heavy gauge entrance cable can move easily through the conduit to the meter base.

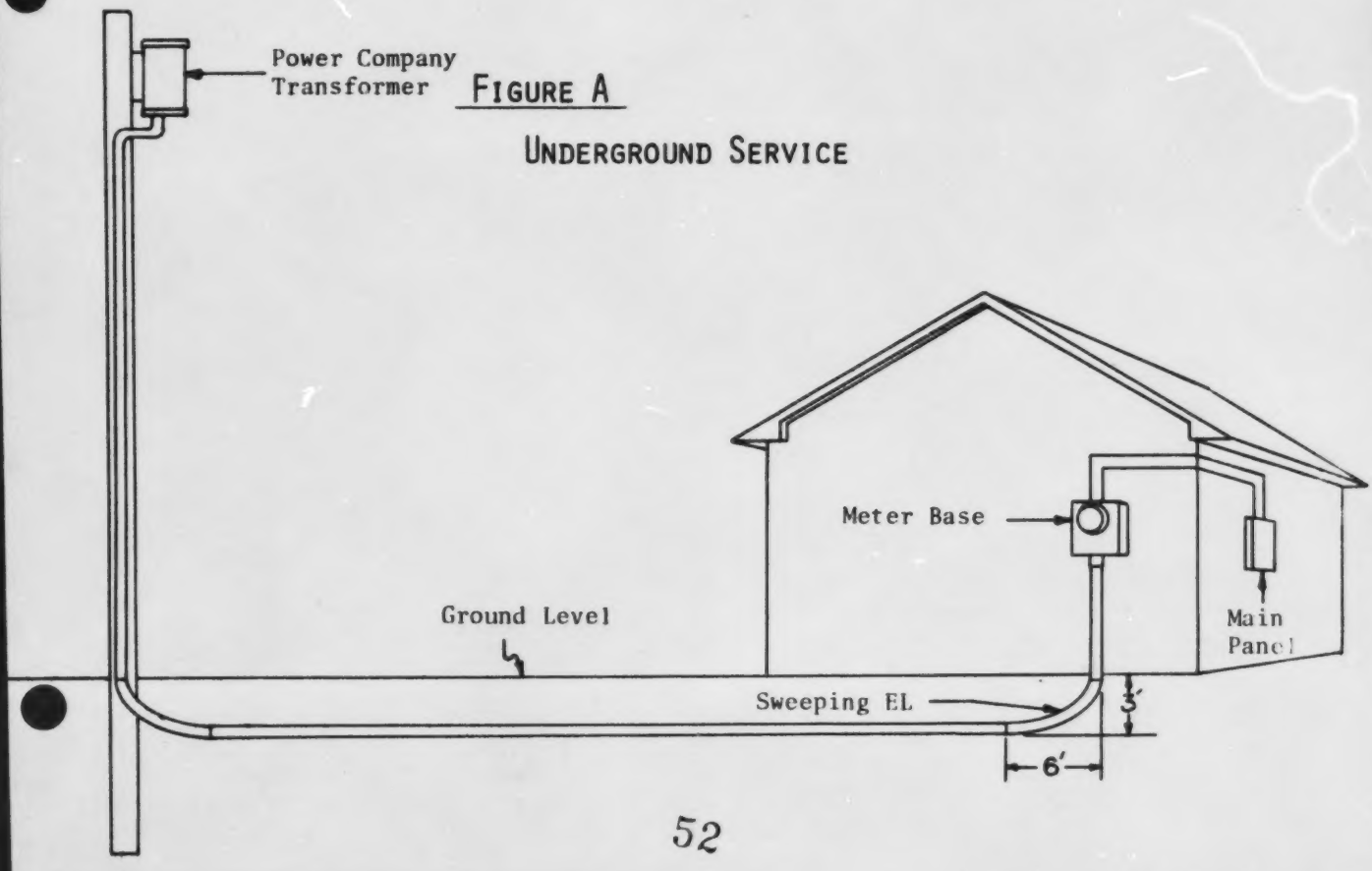


FIGURE A

UNDERGROUND SERVICE

The overhead service entrance can be attached at the roof gable or to a conduit mast which extends above the roof. Clearance from the ground may require that the mast be utilized to meet minimum ground clearance standards. According to the National Electric Code the minimum clearance over sidewalks, platforms or porches should be no less than ten feet (10'). Basic wiring procedures will be similar for either method.

FIGURE B

OVERHEAD EXPOSED GABLE ENTRANCE

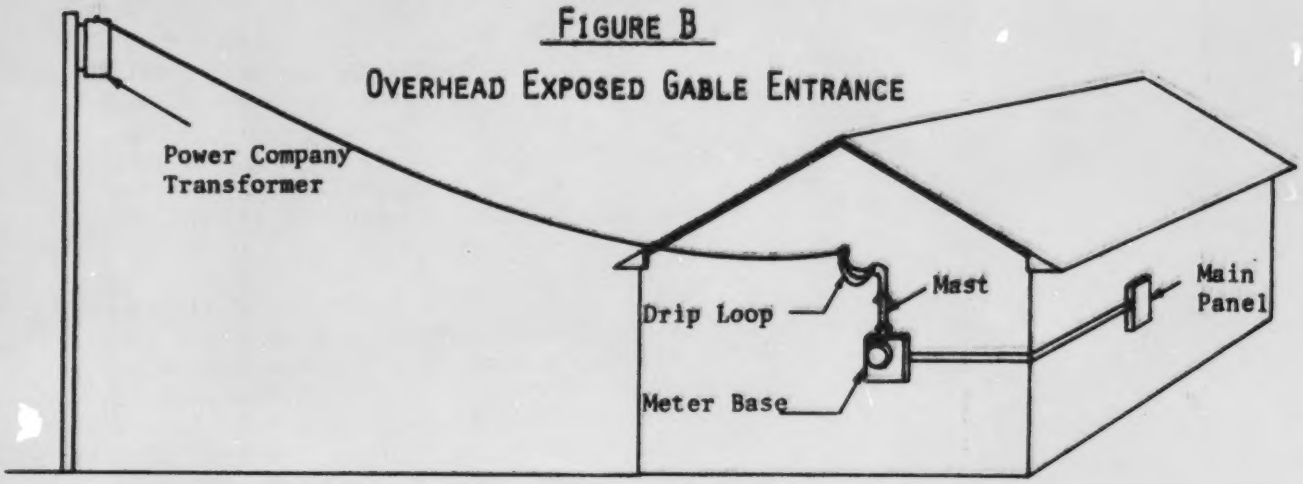
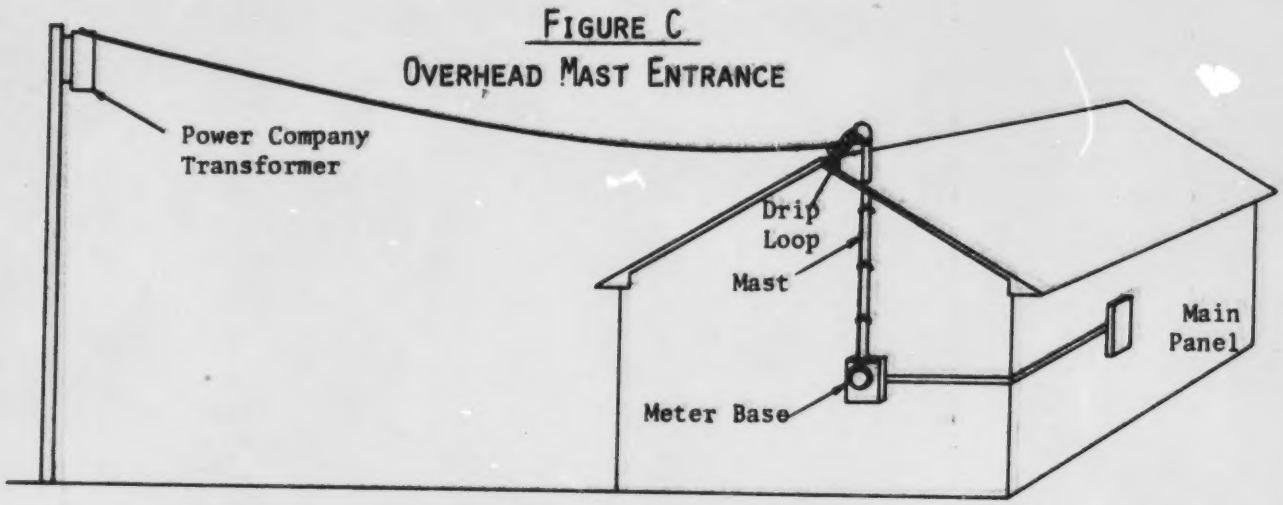


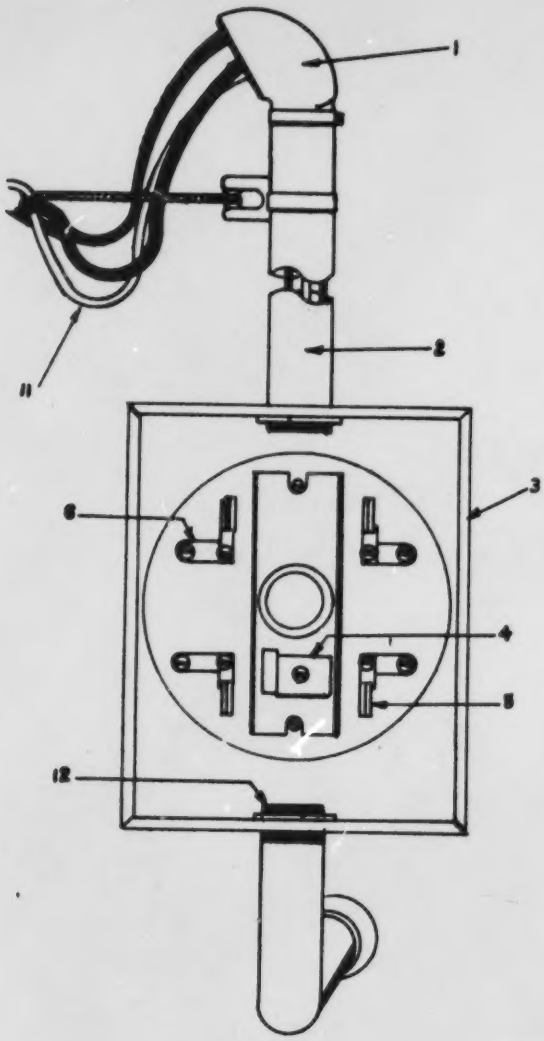
FIGURE C

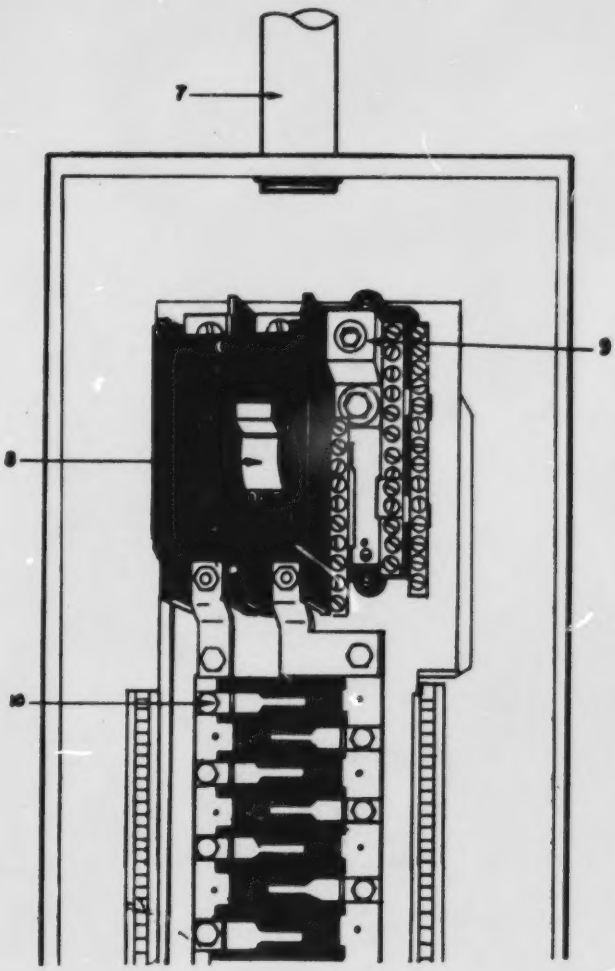
OVERHEAD MAST ENTRANCE



The purpose of the service entrance is to safely transfer the electrical power from the power company transformer outside your home through an electric meter and into your main distribution panel.

Draw and label the components of a service entrance to the point of connection in the distribution panel. Include size of wire, type of wire, and the purpose it serves in the electrical service. (Ground, 110v, 230v, etc.). Draw wires to the points of connection and color code.





1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____

The instructor will assign an area in the lab to install a service entrance. Make sure to include the following components and follow the procedures suggested below:

1. Meter base
2. Mast
3. Weatherhead
4. Service entrance wire

Procedures:

1. Mount meter base:
   a. Knock out plugs needed for mounting screws.
   b. Should be 60" from the center of the meter to the ground.
   c. Secure with #14 x ½" screws.
2. Lay out hole for mast:
   a. Use a level or plumb bob for accuracy.
3. Drill a pilot hole and cut to the size of mast conduit.
4. Place the mast in the hole from above the roof and screw it into the hub of the meter base.
5. Install the entrance cable through the meter base and up through the mast. (3½' of cable should extend from the top of the mast).
6. Prepare the wires and install the weatherhead. (Wires should be inserted into holes of the weatherhead).
7. Coat the aluminum wires with an inhibitor paste and attach to the meter base.

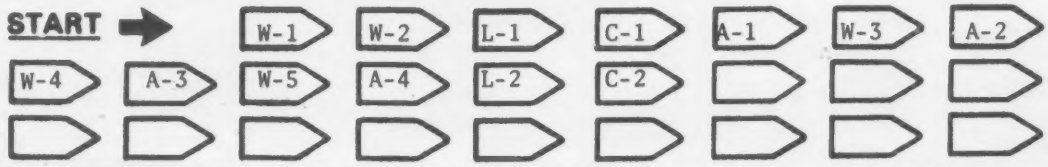
MAJOR BLOCK Residential Wiring **NAME** _____

TASK Service Entrance

UNIT Install Main Panel **TIME (est.)** _____ **(act.)** _____

UNIT NO REW-09

OBJECTIVE(S) Install and wire service entrance cable and main panel.



WRITTEN ASSIGNMENT(S)

W-1	Text Assignment REW-09a
W-2	Information Sheet REW-09a
W-3	Text Assignment REW-09b
W-4	Information Sheet REW-09b
W-5	Assignment Sheet REW-09a
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set REW-09a
A-2	Slide Set REW-09b
A-3	Slide Set REW-09c
A-4	Slide Set REW-09d
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet REW-09a
L-2	Job Sheet REW-09b
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

Distribution Panel

The distribution panel in a home does just what its name implys. It distributes the incoming power to various loads or circuits in the home through protective devices which break the circuit inside the panel. The circuit can be limited or broken with fuses or circuit breakers depending upon the type panel preferred by the customer. Fuse panels and breaker panels are both available in different sizes and types, however, the breaker panels are more popular in most installations.

The incoming voltage to most homes is 230 volts single phase. The distribution panel divides the 230 volts into 115 volt circuits. This is done because most homes require the use of both types of voltage.

The distribution panel is sized according to its current carrying capacity. The size panel used in a particular home would be determined by the size of the home and the number of appliances and outlets in the home. The three common sizes used are the 100 amp for smaller homes and apartments, 150 amps for medium homes with gas heat, and 200 amps for large homes with electric heat. Note the three types and sizes below. Note the ground bar location in each panel. The

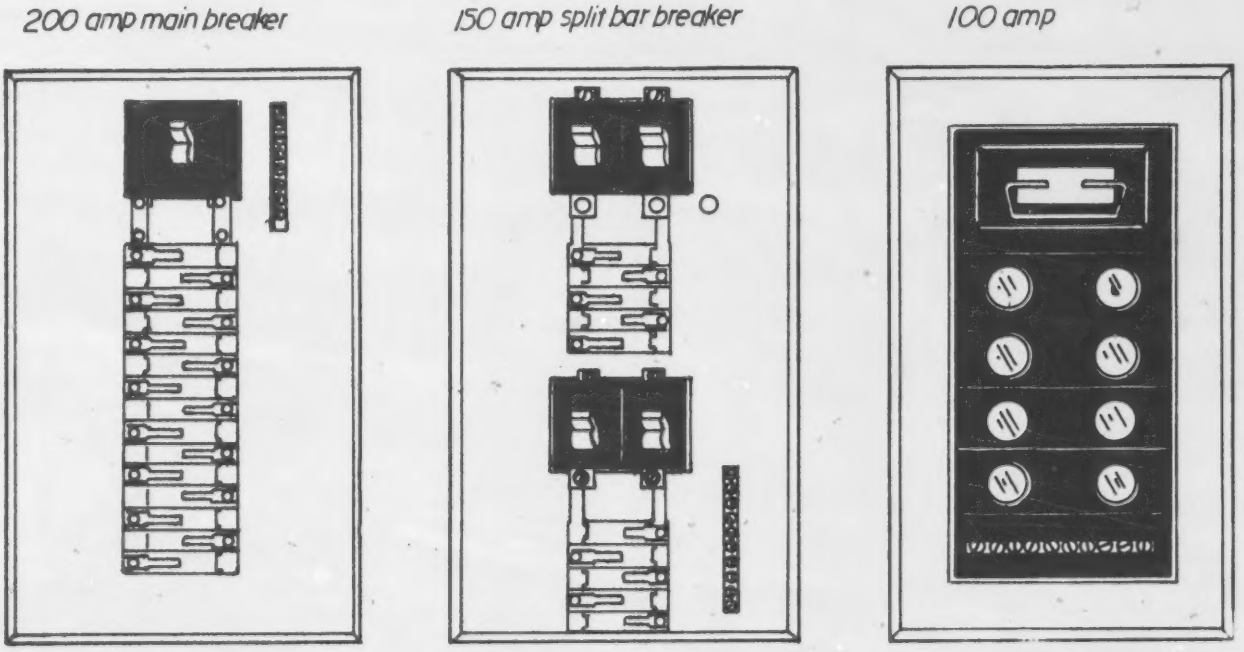


FIGURE A

ground bar is for grounding the system. All neutral connections are made to this bar also. The 100 amp double entrance would require the use of two panels. One is equipped with a main controlling utility circuits such as lights, receptacles and small appliance outlets. The second panel is equipped with a 230 volt source controlling appliances such as ranges, hot water heaters and electric heat.

The main breaker type contains a bus bar arrangement. A 110-115 volt circuit is pulled from each leg of the bus bar. When 220-230 volt circuits are needed a breaker or a combined pair of breakers would receive current from two concurrent legs. (One from each bus.)

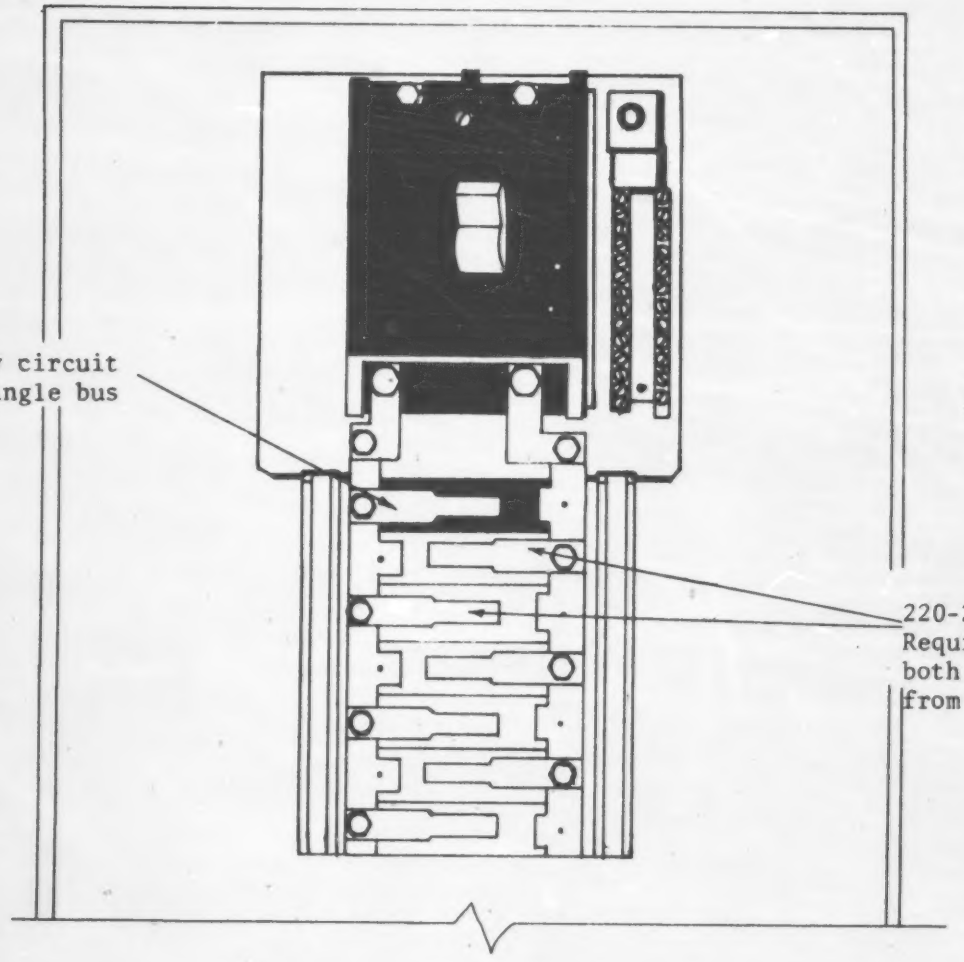


FIGURE B

Grounding

It is necessary for all circuitry within the building to be grounded to the distribution panel. This is normally done through the use of a grounding bar located within the distribution panel. A separate lug supports the neutral and grounding leg of each circuit.

The National Electric Code also requires that the system be grounded. This is done by grounding the distribution panel to an electrode which is driven into the ground of the outside of the structure. The electrode usually takes the form of a ½" copper rod approximately 8' long. It is connected to the panel by a bare copper conductor and ground clamps. Local codes and the National Electric Code gives the minimum requirements for such grounding apparatus.

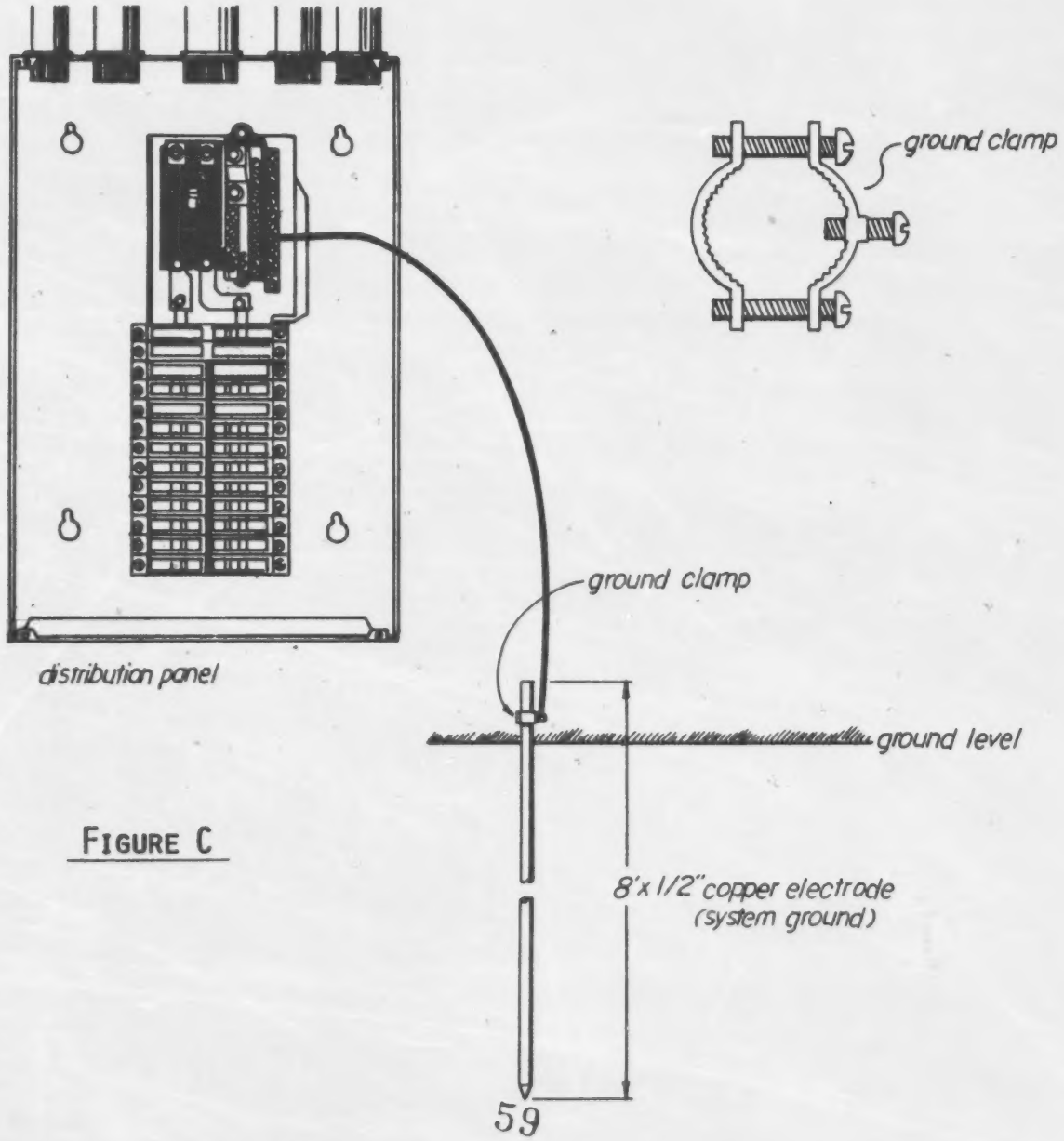


FIGURE C

Locate at least three types and sizes of distribution panels in the laboratory. Fill in the information below on each one. Show this work to your instructor for a check.

Panel #1

Main breaker ampacity _____

Main fuse ampacity _____

Fuse type _____

Breaker type _____

Total panel ampacity _____

230 Volt circuits available _____

Main entrance cable required _____

Panel #2

Main breaker ampacity _____

Main fuse ampacity _____

Fuse type _____

Breaker type _____

Total panel ampacity _____

230 Volt circuits available _____

Main entrance cable required _____

Panel #3

Main breaker ampacity _____

Main fuse ampacity _____

Fuse type _____

Breaker type _____

Total panel ampacity _____

230 Volt circuits available _____

Main entrance cable required _____

Refering to the National Electric Code as a guide to the correct conductor and size, design the grounding system for a main panel. The design should keep in mind the local power company's requirements (e.g. some require an attachment into the service panel while others require attachment to the meter socket).

Design the grounding system utilizing all of the following component parts. Draw and label each part in the appropriate position.

1. Distribution panel (size and type)
2. Electrode
3. Ground clamp
4. Conductor (size and type)

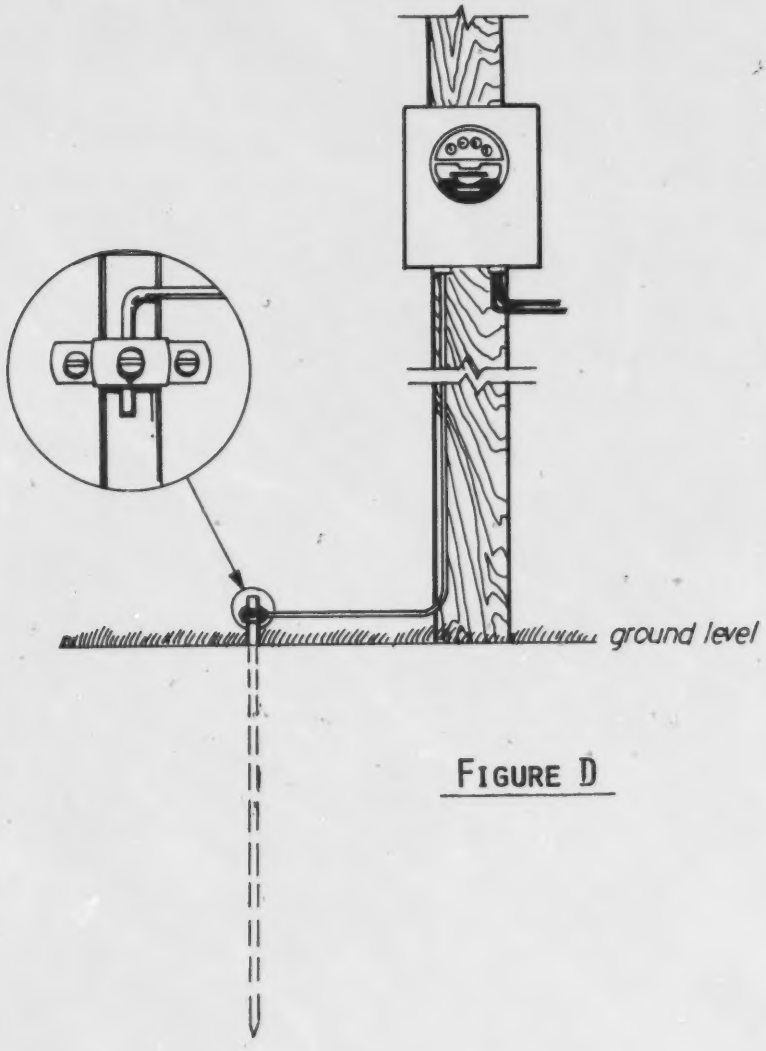


FIGURE D

The instructor will assign either a 100 amp, 150 amp, or a 200 amp distribution panel to wire. Make a list of all the material needed to install this panel properly. The instructor will assign a location to install the panel. Include a distribution panel, one branch circuit, system ground electrode, ground clamp, and the conductor for the system ground.

Procedure:

1. Mount distribution panel.

2. Prepare and install branch circuit.

3. Install system ground.
   a. Ground clamp
   b. Electrode

4. Install the system ground conductor.

MAJOR BLOCK Residential Wiring **NAME** _____

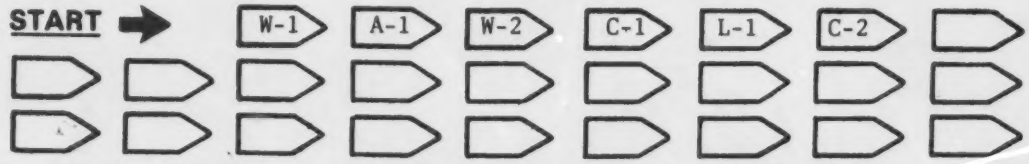
TASK Service Entrance

UNIT Temporary Service **TIME (est.)** _____ **(act.)** _____

UNIT NO REW-10

OBJECTIVE(S)

Install a temporary service



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet REW-10
W-2	Assignment Sheet REW-10
W-3	
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set REW-10
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet REW-10
L-2	
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

The illustration in Figure A is a typical temporary service. A temporary service is normally used in situations where a building is under construction and the builders need power for utility lights, power saws and drills, and other equipment. The temporary service will provide both 115 volt and 220 volt service and is rated at 60 amps. As a minimum, six guage wire is used for entrance cable.

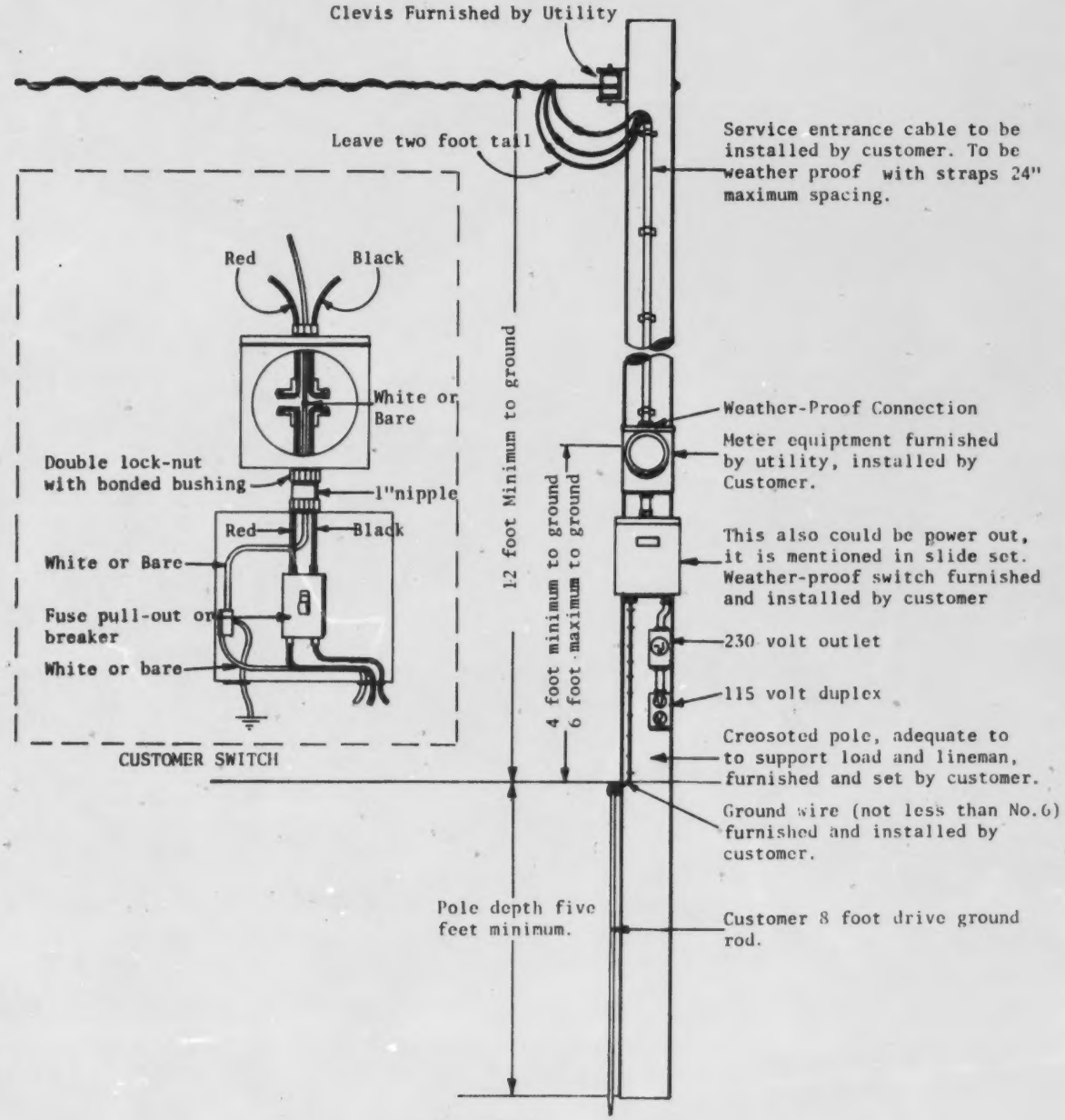

Clevis Furnished by Utility
Leave two foot tail
Service entrance cable to be installed by customer. To be weather proof with straps 24" maximum spacing.
Red
Black
White or Bare
Double lock-nut with bonded bushing
1"nipple
Red
Black
White or Bare
Fuse pull-out or breaker
White or bare
CUSTOMER SWITCH
12 foot Minimum to ground
4 foot minimum to ground
6 foot maximum to ground
Weather-Proof Connection
Meter equiptment furnished by utility, installed by Customer.
This also could be power out, it is mentioned in slide set. Weather-proof switch furnished and installed by customer
230 volt outlet
115 volt duplex
Creosoted pole, adequate to to support load and lineman, furnished and set by customer.
Ground wire (not less than No.6) furnished and installed by customer.
Pole depth five feet minimum.
Customer 8 foot drive ground rod.

FIGURE A

Designing a Temporary Service Pole Installation

Design a service pole installation. Draw and label all wires, splices, grounds and fixtures needed to provide two 115 volt and one 230 volt outlets rated at 60 amps. (Include the following fixtures: meter base, 230 volt power outlet box, fuse or breaker panel and duplex 115 volt outlet),

Installing a Temporary Service

Procedure:

1. Obtain the temporary service pole design for Assignment Sheet REW-11a.
2. List the materials needed for the installation.
3. Consult the instructor to determine that the circuit design is corrct and the materials list is complete.
4. Make the temporary installation according to the National Electric Code requirements.
   (A pole for installing a temporary service will be available in the lab area).

MAJOR BLOCK Residential Wiring **NAME** _____

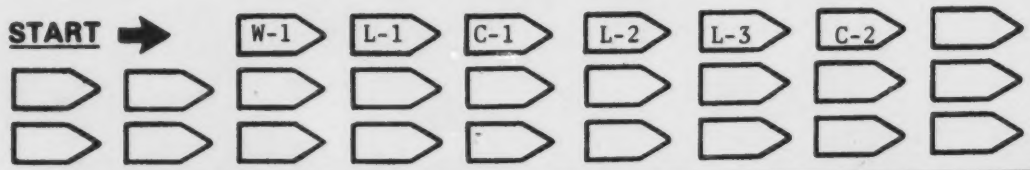
TASK Blueprint Reading

UNIT Using Standard Measurements **TIME (est.)** _____ **(act.)** _____

UNIT NO. REW-11

OBJECTIVE(S)

Identify the graduations of standard measurement and measure electrical devices.



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet REW-11a
W-2	
W-3	
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet REW-11a
L-2	Job Sheet REW-11b
L-3	Job Sheet REW-11c
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

One common skill in which all electrical workers must be well qualified is measurement. Anyone employed in the electrical trades must be able to read and use common layout and measuring devices related to their specific areas.

A careful study of the enlarged section of the rule below will show the different fractional divisions of an inch from 1/8" to 1/16". The lines representing the divisions are called GRADUATIONS. The best way to learn to read the rule is to,

1. Become thoroughly familiar with the 1/8 and 1/16 measurements.
2. Practice until you become proficient enough to read measurements accurately and quickly.

Fractional measurements are always reduced to the lowest terms. A measurement of 14/16 is 7/8; 2/8 is 1/4, etc. Each inch is really 1/12 foot. Each division within an inch is 1/16" even though there is no marking to indicate it.

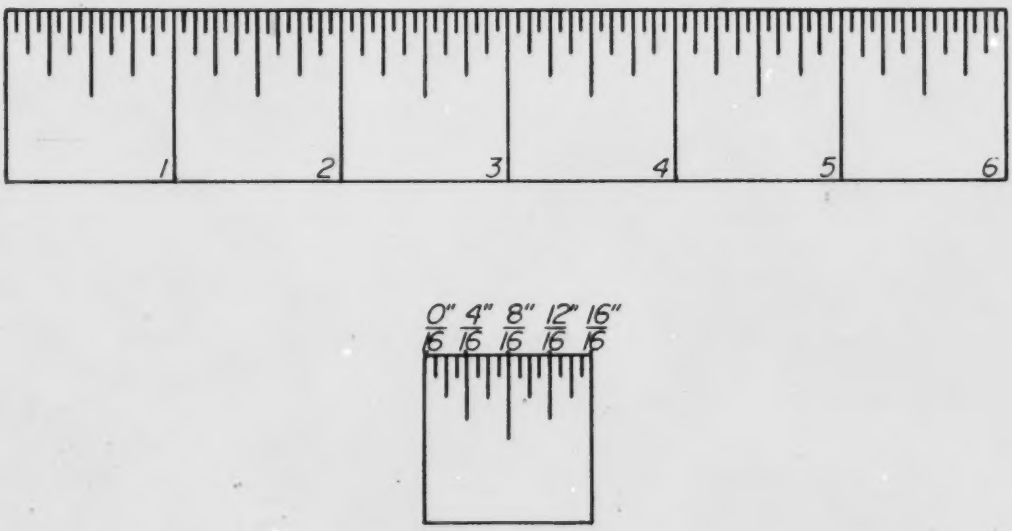


FIGURE A

When dealing with fractions or reading measurements one must remember the following information:

A. 2/2 = 1"

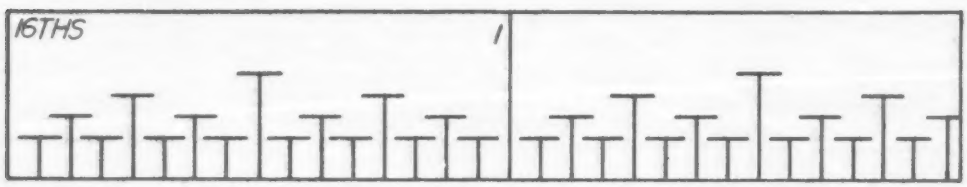
B. 4/4 = 1"

C. 8/8 = 1"

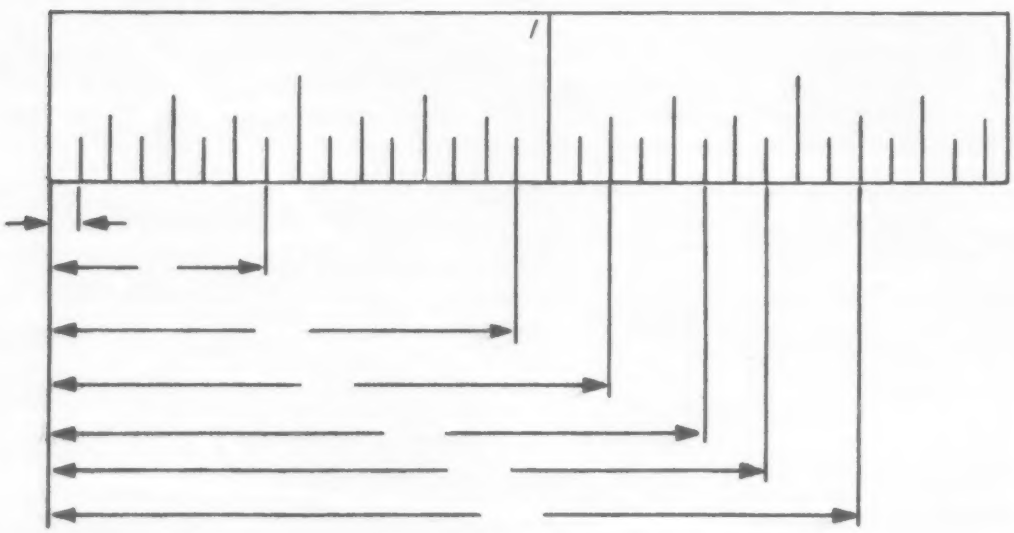
D. 16/16 = 1"

One must also remember that measurement of fractions are expressed in its lowest common denominator.

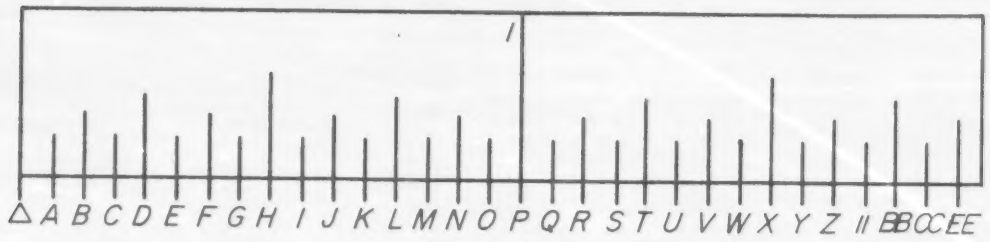
Identify the following measurements on the blank above each mark:



Identify the following lines by placing the measurement in the space provided on dimension lines.



Using the diagram below answer the following questions on measurement and fractions:



1. What is the distance from:

   a. △to M? _____

   b. E to Z? _____

   c. R to T? _____

   d. L to M? _____

   e. B to K? _____

2. What is the length of:

   a. Q _____

   b. H _____

   c. V _____

   d. T _____

   e. F _____

3. How many 16ths are in:

   a. 1 1/2" _____

   b. 3/4" _____

   c. 9/16" _____

   d. 1 1/4" _____

5. 1/2 + 1/4 = _____

6. 3/8 - 1/4 = _____

7. 3/16 + 3/4 = _____

8. (5/8 + 7/16) - 1/4 = _____

9. Distance from G to T minus the distance of L to Q. _____

10. What is the measurement of EE? _____

The instructor will assign several outlets, boxes and switches to measure. The distance from the device to the floor should be recorded in the chart below.

	Name of Item	Distance from Floor/Size
Item #1		
Item #2		
Item #3		
Item #4		
Item #5		

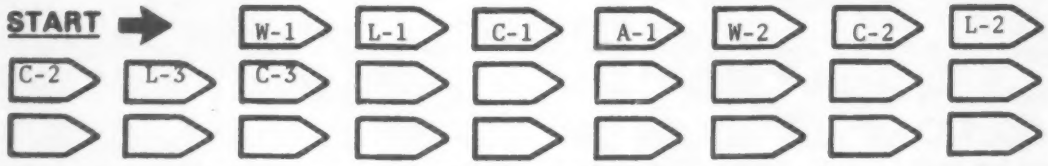
MAJOR BLOCK Residential Wiring **NAME** _____

TASK Blueprint Reading

UNIT Identifying Residential Wiring Symbols and Designing Circuits **TIME (est.)** _____ **(act.)** _____

UNIT NO REW-12

OBJECTIVE(S) The student will be able to identify and draw most electrical symbols used in residential wiring.



WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REW-12a
W-2 Assignment Sheet REW-12a
W-3 _____
W-4 _____
W-5 _____
W-6 _____
W-7 _____

AUDIOVISUAL(S)

A-1 Slide Set REW-12a
A-2 _____
A-3 _____
A-4 _____
A-5 _____
A-6 _____
A-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REW-12a
L-2 Job Sheet REW-12b
L-3 Job Sheet REW-12c
L-4 _____
L-5 _____
L-6 _____
L-7 _____
L-8 _____
L-9 _____

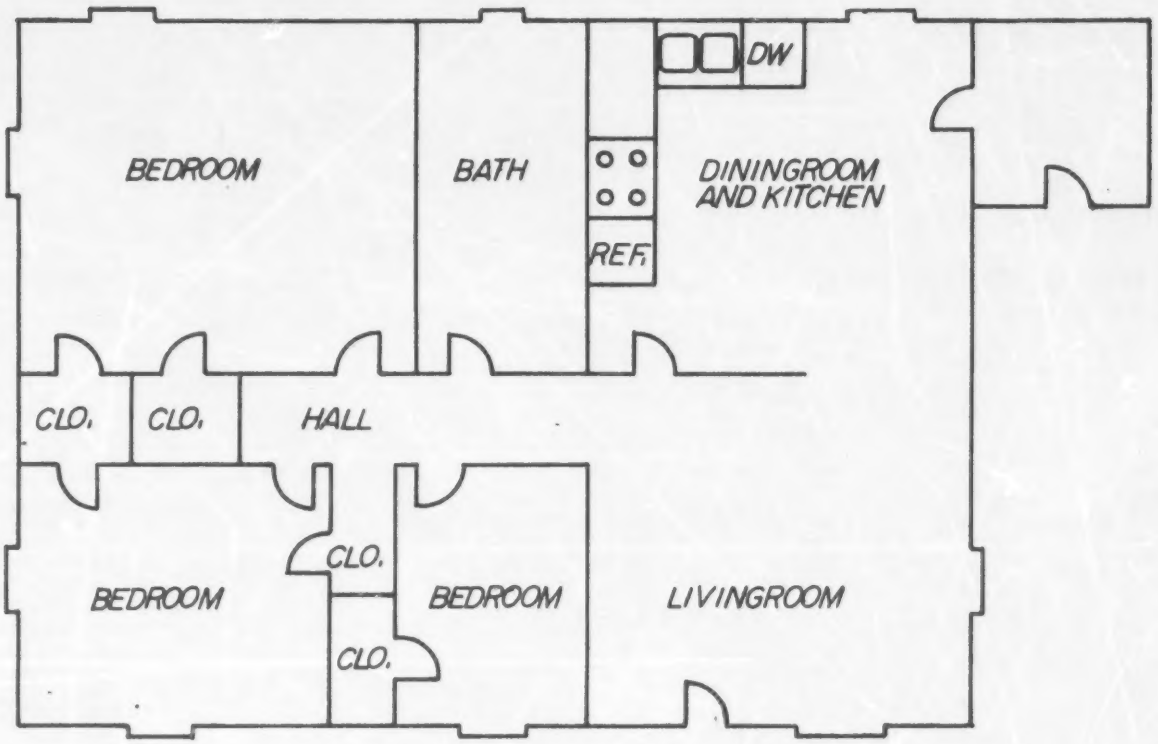
CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 _____
C-5 _____
C-6 _____
C-7 _____
C-8 _____
C-9 _____

After becomming familiar with wiring techniques the electrician should become familiar with designing potential circuits for installation. As a reference in designing these circuits the student is referred to the NEC article 220, parts A and B. In order to make proper and safe circuit calculations the student should become familiar with this section of the Code.

Three watts per square foot is recommended by the code. It also states that a minimum of two appliance outlets rated at 1500 watts each (use the power formula to convert to amps) should be used in a single family dwelling. In addition, most 220 volt appliance allowances are found in article 220-30 of the code. The power formula should be used to find amperage and table 310-16 should be used to find the site required for all circuits.

Below is a list of lighting and convenience outlets needed in each room. Draw them in and include wiring. Remember rules learned in the NEC. Show work to instructor.



Living Room

One overhead light

Six 110 volt outlets

3-way switch for light

Dining Room and Kitchen

Two overhead lights

Eight 110 volt outlets

Hall

1 overhead light

3-way switch

2 110 volt outlets

Bedrooms

1 overhead light

1 wall switch

4 110 volt outlets

Bathroom

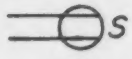
1 overhead light

1 switch

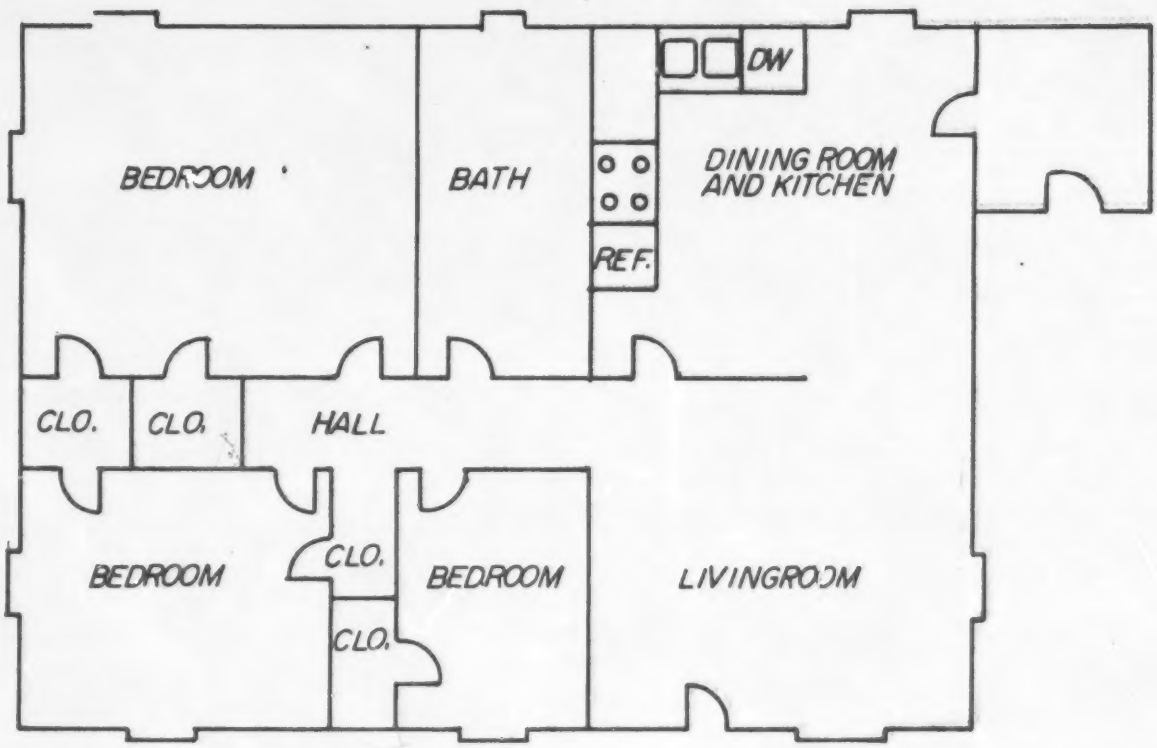
1 lighted medicine cabinet

Service Entrance

To be located on the outside wall in utility room

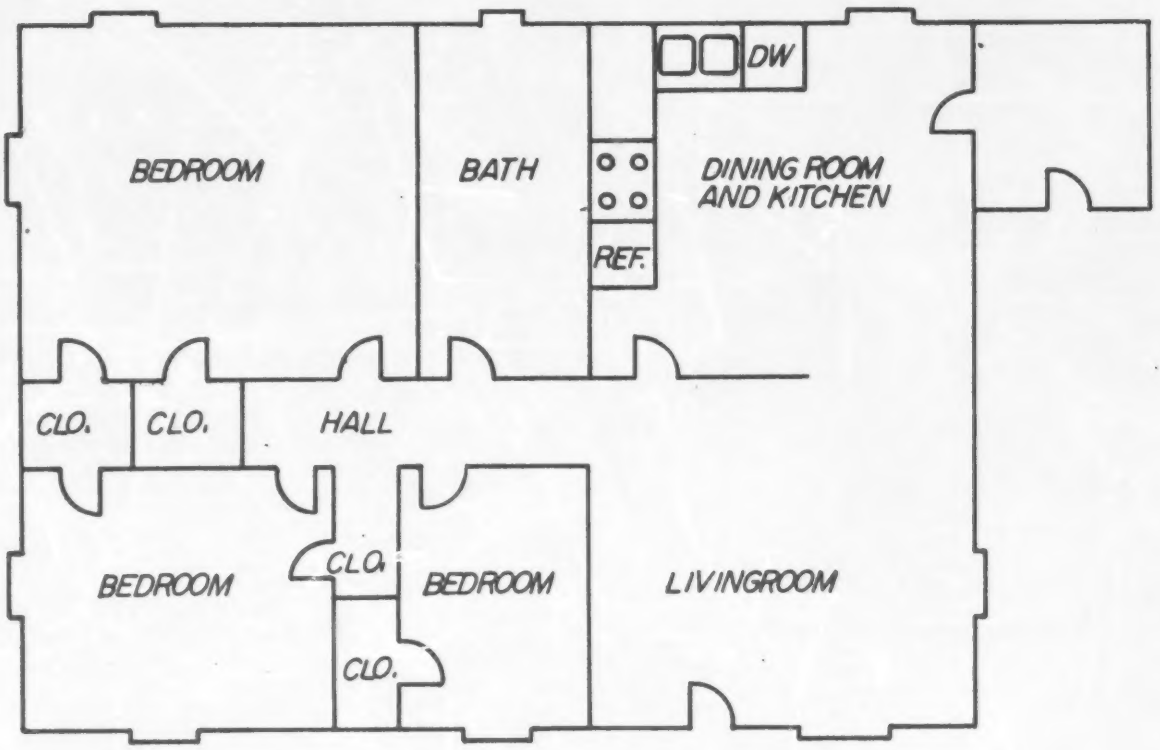
_____	1.	a. Lighting outlet
_____	2.	b. Ceiling outlet for recessed fixture
_____	3.	c. Lighting outlet with lampholder
_____	4.	d. Fan outlet
_____	5.	e. Lighting outlet with pull switch
_____	6. 	f. Clock outlet
_____	7.	g. Duplex convenience outlet
_____	8.	h. Duplex convenience outlet (split wired)
_____	9.	i. Duplex convenience outlet for grounding-type plugs
_____	10.	j. Weatherproof convenience outlet
_____	11.	k. Combination switch and convenience outlet
_____	12.	l. Floor outlet
_____	13.	m. Range outlet
_____	14.	n. Special purpose outlet (dishwasher)
_____	15.	o. Single-pole switch
_____	16.	p. Three-way switch
_____	17.	q. Four-way switch
_____	18.	r. Switch and pilot light
_____	19.	s. Push button
_____	20.	t. Chime
_____	21.	u. Bell ringing transformer
_____	22.	v. Outside telephone
_____	23.	w. Interconnecting telephone
_____	24.	x. Television outlet
_____	25.	y. Distribution or service panel

Below is a list of 115v appliance outlets needed in the house. Draw them in and include wiring. Remember rules learned in the NEC. Show work to instructor.



Kitchen	Bedroom AC
115 v DW	115 v AC
115 v REF	115 v AC
Utility	115 v AC
115 v WM	Service
	To be located on outside wall of utility room

Below is a list of 220 v outlets required in the house. Draw in the circuits and outlets. Remember rules learned in the NEC. Show your plan to your instructor when complete.



Below is a list of things that are needed in each room.

Living Room

1 220 volt outlet

Dining Room and Kitchen

1 220 volt outlet

Service Entrance

To be located on the outside wall in the utility room (2 220 volt outlets)

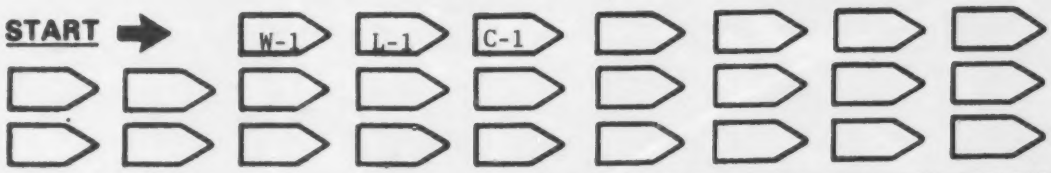
MAJOR BLOCK Residential Wiring **NAME** _____

TASK Blueprint Reading

UNIT Estimating Materials **TIME (est.)** _____ **(act.)** _____

UNIT NO REW-13

OBJECTIVE(S)



WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REW-13a
W-2 _____
W-3 _____
W-4 _____
W-5 _____
W-6 _____
W-7 _____

AUDIOVISUAL(S)

A-1 _____
A-2 _____
A-3 _____
A-4 _____
A-5 _____
A-6 _____
A-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REW-13a
L-2 _____
L-3 _____
L-4 _____
L-5 _____
L-6 _____
L-7 _____
L-8 _____
L-9 _____

CHECKPOINT(S)

C-1 Instructor Check
C-2 _____
C-3 _____
C-4 _____
C-5 _____
C-6 _____
C-7 _____
C-8 _____
C-9 _____

Cost Estimation from Blueprints

When estimating the cost involved in completing a residential wiring job, many factors must be considered. Since methods for determining labor costs vary from area to area (depending upon local practices) only methods of determining material estimates will be dealt with in this unit.

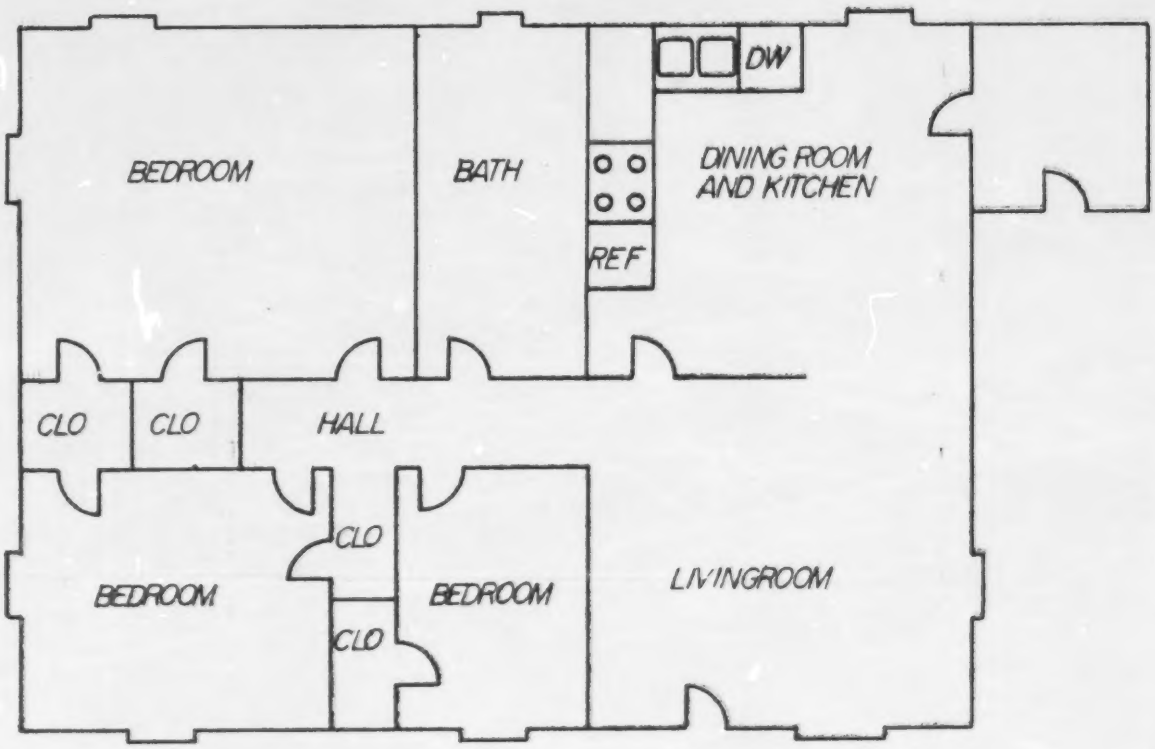
The most accurate procedure for estimating materials is the take-off method. As an overview of this method, the person making the estimate lists all the materials needed on the job, determines prices for each item, then totals everything.

Points to Consider when Estimating Materials

The student should note when doing Job Sheet REW-13a that all outlets must have wall boxes or ceiling boxes and hardware to mount them. Also remember that wire must be run for feeds and switch legs. The number of circuits must be determined in order to determine the size of the panel, the size and number of breakers required, and the number of connectors needed to tie in wires to the panel. The length of wire should be estimated by scaling the length of each circuit. (If labor must be estimated, the electrician may count the number of electrical outlets or drops to be included in the house. These must be taken from the house blueprint.)

Job Sheet REW-13a

RESIDENTIAL WIRING WORK SHEET



Below is a list of things that are needed in each room. Draw them in and make a material and price list for this house. Show work to the instructor when completed.

Living Room

One overhead light
Six 110 volt outlets
One 220 volt outlet
3-way switch for light

Dining Room and Kitchen

Two overhead lights
Eight 110 volt outlets
One 220 volt outlet

Hall

One overhead light
3-way switch
Two 110 volt outlets

Bedrooms

One overhead light
One wall switch
Four 110 volt outlets

Bathroom

One overhead light
One switch
One lighted medicine cabinet

Service Entrance

To be located on the outside wall in the dining room and kitchen

RESIDENTIAL WIRING INFORMATION SHEET
Price List as of 5/14/80

Weatherhead	$ 4.36
Conduit (2")	16.82
L.B's (2")	11.65
Breaker - 100 amp	48.56
200 amp	98.32
3'0 Wire (20 circuit)	8.92
No. 2/3 Covered Wire	.64 ft.
No. 2 Copper Wire	3.35 ft.
Ground rod	4.15
Ground rod clamp	.53
Plastic bushings (2")	.46
Lock nuts	.32
1/2" connector	.15
12-2 wg. wire	.15
10-2 wg wire	.22
Wall boxes	.65
Ceiling boxes	.74
Single pole switches	.75
3-way switches	1.06
4-way switches	$6.59
220 outlets (1876)	1.97
Range cable	.99
Range receptacle	3.20
Soldering	7.25
Tape	.90
Keyless receptacle	.97
Roof flange	3.50
Fuses	.42
Light Bulbs	.37
Conduit clamps	.56
L.B. cover	
Plug fuse	.42
Romex staples	1.06
Pull chain receptacle	1.37
No. 4 ground wire	.50
Covers	.20
Single pole breakers	3.60
Double pole breakers	8.09